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19.0 CLIMATE CHANGE

19.1 Introduction

19.1.1 This chapter of the Preliminary Environmental Information (PEI) Report considers the potential impacts and effects of Proposed Development construction, operation (including maintenance) and decommissioning on the climate, as well as the impacts of climate change on the Proposed Development and surrounding environment.

19.1.2 The assessment has been undertaken in accordance with the requirements of guidance from the Institute of Environmental Management and Assessment (IEMA) for Assessing Greenhouse Gas the Evaluating their Significance (IEMA, 2022) and Climate Change Resilience and Adaptation (IEMA, 2020) has been applied. This chapter addresses three separate aspects:

- Lifecycle Greenhouse Gas (GHG) impact assessment – the potential effects on the climate from GHG emissions arising from the Proposed Development, including how the Proposed Development would affect the ability of the UK Government to meet its carbon reduction targets;
- Climate Change Resilience (CCR) assessment – the resilience of the Proposed Development to projections for climate change, including how the Proposed Development design will be adapted to take account of the projected impacts of climate change; and
- In-combination climate change impacts (ICCI) assessment – the in-combination effects of a changing climate and the Proposed Development on receptors in the surrounding environment.

19.1.3 This chapter is supported by:

- Appendix 19A: Climate Change Resilience Assessment (PEI Report, Volume III).

19.2 Legislation and Planning Policy Context

<u>Legislative Background</u>

19.2.1 This section identifies legislation, policy and guidance of relevance to the assessment of the potential impacts associated with the Proposed Development. Legislation, policy and other relevant guidance has been considered on an international, national and local level.

International Legislation

Paris Agreement (2015)

19.2.2 The Paris Agreement is an agreement under the United Nations Framework Convention on Climate Change (UNFCCC) dealing with GHG emissions mitigation, adaptation and finance starting in the year 2020. It requires all signatories to strengthen their climate change mitigation efforts to keep the increase in global average temperature to well below 2°C this century above pre-industrial levels and to pursue efforts to limit the increase to 1.5°C (UNFCCC, 2016). This ambition is addressed in Section 19.3.

National Legislation

The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

19.2.3 The 2017 Regulations (UK Government, 2017) state that an EIA (where relevant):

"must include a description of the likely significant effects of the development on the environment resulting from … the impact of the project on climate (for example the nature and magnitude of greenhouse gas emissions) and vulnerability of the project to climate change".

19.2.4 This requirement is addressed in Sections 19.3 and 19.4.

Climate Change Act 2008/ Climate Change Act (2050 Target Amendment) Order 2019

19.2.5 The Climate Change Act 2008 (UK Government, 2008) set a legally binding target for the UK to reduce its greenhouse gas emissions from 1990 levels by at least 80% by 2050. This target is supported by a system of legally binding five-year 'carbon budgets' and an independent body to monitor progress, the Climate Change Committee (CCC). The UK carbon budgets restrict the amount of GHG emissions the UK can legally emit in a defined five-year period.

19.2.6 The Act was amended in 2019 to revise the existing 80% reduction target and legislate for net zero emissions by 2050 (through the Climate Change Act 2008 (2050 Target Amendment) Order 2019) (UK Government, 2019).

19.2.7 In 2020, the 6th carbon budget (Climate Change Committee, 2020) was published by the CCC for consideration by government and is the first budget to reflect the amended trajectory to net zero by 2050.

19.2.8 The existing UK carbon budgets are used to determine significance of GHG emissions from the Proposed Development, as described in Section 19.3.

UK Nationally Determined Contribution (2020)

19.2.9 Under Article 4 of the Paris Agreement, parties are required to communicate their intended domestic GHG mitigation targets. In 2020, the UK communicated its new Nationally Determined Contribution to the UNFCCC. Within this, the UK has committed to reducing GHG emissions by at least 68% by 2030 compared to 1990 levels (UK Government , 2022).

Planning Policy Context

National Planning Policy

Overarching National Policy Statement for Energy (EN-1) (2011)

19.2.10 Published by the Department of Energy and Climate Change (2011a), the National Policy Statement (NPS) EN-1 describes the national policy for energy infrastructure in relation to climate impacts and adaptation; adverse effects and benefits; in relation to the European Union (EU) Directive and environmental assessment requirements; and in relation to adaptation measures in response to climate projections; and in relation to climate projections, flood risk and the importance of relevant mitigation.

19.2.11 EN-1 promotes Carbon Capture and Storage (CCS) as an emerging technology that the government is aiming to facilitate and encourage. Paragraph 2.2.23 of EN-1 states that CCS is part of the UK's plans to *"reduce its dependence on fossil fuels, particularly unabated combustion"*.

19.2.12 In March 2023, the Department for Energy Security and Net Zero (previously the Department for Business, Energy, and Industrial Strategy (BEIS)) published an update of the existing statement (NPS EN-1). The Draft EN-1 sets out that energy transformation is needed including renewables and "*hydrogen manufactured using low carbon processes (low carbon hydrogen) and, where we still emit carbon, developing the industry and infrastructure to capture transport and store it."* Paragraphs 3.4.12 to 3.4.21 of the document discuss the need for hydrogen as part of a decarbonised energy system (Department for Energy Security and Net Zero, 2023).

National Policy Statement for Gas and Oil Pipelines (EN-4) (2011)

19.2.13 The NPS EN-4 sets out policy for energy infrastructure in the UK (Department of Energy and Climate Change, 2011b). Section 2.2 of the legislation sets out the need to transition to a low carbon economy and the need to ensure that adaptation planning is embedded into planning on new energy NSIPs. Section 4.7 sets out the need for CCS as an emerging technology to be enabled with pipeline and storage networks. Section 4.8 of this NPS sets out the need for applicants to take the effects of climate change into account when developing and consenting infrastructure, which includes undertaking a Climate Change Risk Assessment.

National Policy Statement for Electrical Networks Infrastructure (EN-5) (2011)

19.2.14 NPS EN-5 sets out policy on assessments of impacts across a range of technologies associated with energy and electricity networks infrastructure (Department of Energy and Climate Change, 2011c). Section 2.4 sets out the requirements of an assessment of infrastructures resilience to climate change. In particular any assessment is expected to consider how vulnerable or resilient it would be to flooding, winds and storms, higher temperatures or earth movement caused by flooding or drought.

Draft Overarching NPS for Energy (EN-1) (2023)

19.2.15 National Policy Statement (NPS) EN-1 describes the national policy for energy infrastructure in relation to climate impacts and adaptation; adverse effects and benefits; in relation to the European Union (EU) Directive and environmental assessment requirements; and in relation to adaptation measures in response to climate projections; and in relation to climate projections, flood risk and the importance of relevant mitigation (Department for Energy Security and Net Zero, 2023).

19.2.16 Paragraph 2.4.4 commits to developing business models to incentivise CCS and low carbon hydrogen production in the UK, and business models for hydrogen transport and storage. Paragraph 3.4.12 to 3.4.21 highlights the role of low carbon hydrogen in transitioning to a decarbonised energy sector.

Draft National Policy Statement for *Natural Gas Supply Infrastructure and Gas and Oil Pipelines* (EN-4) (2023)

19.2.17 The 2023 draft update to NPS EN-4 relates to energy infrastructure in the UK. Section 2.3 sets out the requirements for climate change adaptation which is expanded to say that any assessment should consider any other increased risks as well as the identified risks of flooding, sea level rise, higher temperatures and earth movements (Department for Energy Security and Net Zero, 2023).

Draft National Policy Statement for Electricity Networks Infrastructure (EN-5) (2023)

19.2.18 The 2023 draft update to NPS EN-5 relates to energy infrastructure in the UK. Section 2.3 sets out the requirements for climate change adaptation which is expanded to say that any assessment should consider any other increased risks as well as the identified risks of flooding, sea level rise, higher temperatures and earth movements (Department for Energy Security and Net Zero, 2023).

The National Planning Policy Framework (2021)

19.2.19 The revised National Planning Policy Framework (NPPF) (Ministry of Housing, Communities and Local Government, 2021) sets out the Government's planning policies for England. While the NPPF does not set specific policies for Nationally Significant Infrastructure Projects (NSIPs), its policies may be of relevance to decision making.

19.2.20 Policies of relevance to climate change include those meeting the challenge of moving to a low carbon economy, climate change, flooding and coastal change (Section 14). The NPPF states that the planning system should support this transition by supporting low carbon energy and associated infrastructure.

National Planning Policy Guidance (NPPG) on Climate Change (2019)

19.2.21 Guidance published by the Ministry of Housing, Communities and Local Government (2019b) describes how to identify suitable mitigation and climate adaptation measures to incorporate into the planning process. It states that "*effective spatial planning is an important part of a successful response to climate change as it can influence the emission of greenhouse gases… Planning can also help increase resilience to climate change impact through the location, mix and design of development*."

Biodiversity Strategy 2020 (2011)

19.2.22 A strategy for England's wildlife and ecosystem services (Department for Environment, Food and Rural Affairs (Defra, 2011) establishes principles for considering biodiversity and the potential effects of climate change. This assessment will reflect these principles and identify how the effects of the Proposed Development on the natural environment will be influenced by climate change, and how ecological networks will be maintained.

Local Planning Policy

North and South Tees Industrial Development Framework (2009)

19.2.23 This framework discusses the need to promote carbon capture and storage networks as an important opportunity for both the North and South Tees, and for the UK to meet its climate change reduction targets (Parsons Brinckerhoff Ltd & Genecon, 2009).

Tees Valley Climate Change Partnership Climate Change Strategy (2010)

19.2.24 This Partnership (made up of the five Tees Valley Local Authorities, the Environment Agency, Renew@CPI, Tees and Durham Energy Advice Centre (TADEA) and the Energy Savings Trust) published the Tees Valley Climate Change Strategy (Tees Valley Unlimited, 2010). The Partnership represents five local neighbouring local authorities and details its strategy for emissions reductions, climate change adaptation and resilience communities.

19.2.25 The combined Tees Valley GHG baseline was calculated as 7,125,000 tonnes of carbon dioxide (CO_2) equivalents (CO_2e) in 2005 as shown in Plate 19-1.

19.2.26 Plate 19-1 also illustrates the Partnership's total emission reductions that would be needed to meet the previous UK Government target of an 80% reduction in emissions by 2050 compared to that in 1990. Tees Valley calculated that their emissions would need to be under 2,000,000 tonnes of CO_2e by 2050 to meet the previous UK target. As set out above, the Climate Change Act (2050 Target Amendment) Order 2019 revised that 80% reduction target to a net zero target (paragraph 19.2.6). The Tees Valley Climate Change Partnership has yet to recalculate their emissions reduction target in light of the revised net zero target, though it would need to still be net zero by 2050 to align with the national target.

19.2.27 Redcar and Cleveland Borough Council (RCBC) and Stockton-on-Tees Borough Council (STBC) have adopted the Tees Valley Climate Change Strategy (Tees Valley Unlimited, 2010). The Council is also a member of UK100, a network of community leaders committed to *"100% clean energy production by 2050".* This enhances the need and commitment for developments that lead to clean energy.

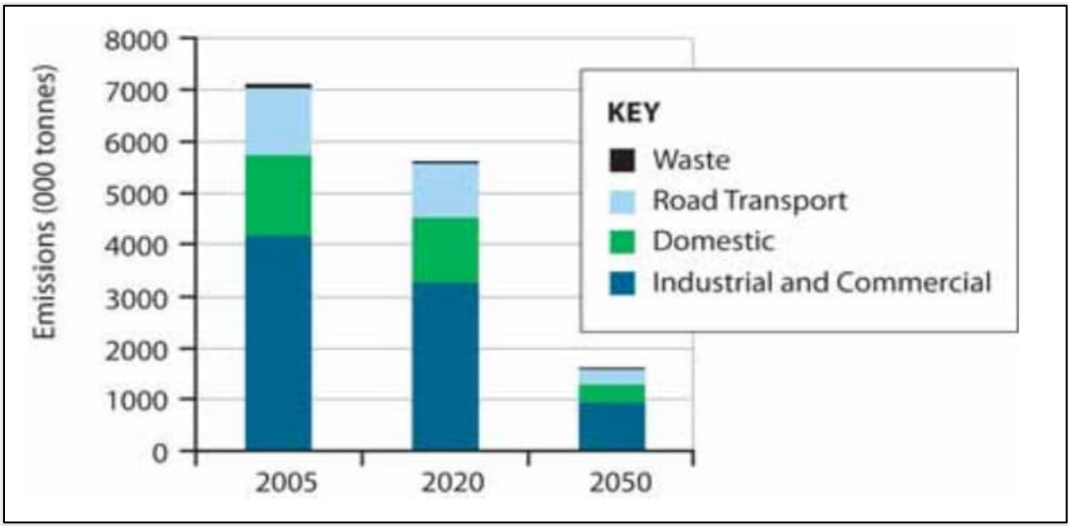

Plate 19-1: Tees Valley GHG Emissions Baseline and Reduction Targets (Taken from Tees Valley Unlimited, 2010)

Redcar and Cleveland Borough Council

Redcar and Cleveland Borough Council Carbon Neutral Declaration (2019)

19.2.28 RCBC declared a climate emergency in March 2019 and have declared an intent to be carbon neutral by 2030 (Redcar & Cleveland Borough, 2019a). This notably includes the support of a carbon capture storage and utilisation network for industry stating *"[to achieve carbon neutrality by 2030] This must include protecting our manufacturing industry and associated jobs by facilitating an industrial Carbon Capture Storage and Utilisation (CCSU) network in our Borough".*

19.2.29 RCBC's Strategic Flood Risk Assessment (JBA Consulting, 2018) is used as guidance for new developments to help avoid increased flooding risks from projections for sea level rise and increased rainfall. As the council is defined as the Lead Local Flood Authority (LLFA) and a Local Planning Authority, Strategic Flood Risk Assessments must be developed as a base for new Local Plans and Sustainability Appraisals. This is described in more detail in Chapter 9: Surface Water, Flood Risk and Water Resources (PEI Report, Volume I).

Redcar and Cleveland Borough Council Local Plan (2019)

19.2.30 RCBC's Local Plan (Redcar & Cleveland Borough Council, 2019b) describes the need for new developments to be *"sustainable in design and construction, incorporating best practice in resource management, energy efficiency and climate change adaptation"* (Redcar & Cleveland Borough Council, 2019b, p. 42) with particular climate change adaptation measures to be incorporated in flood and water management design.

Stockton-on-Tees Borough Council

Stockton-on-Tees Borough Council Climate Strategy and Action Plan (2022)

19.2.31 In 2022, STBC adopted and published its Climate Change Strategy and Action Plan, active until 2032 (STBC, 2022). The strategy details its low carbon vision for the area and the industrial sector being a priority area for emission reductions.

19.2.32 In 2018, STBC completed a Level 1 Strategic Flood Risk Assessment (JBA consulting, 2018), which is used as guidance for new developments in understanding the flood risks of rainfall and sea level rise. More detail can be found in Chapter 9: Surface Water, Flood Risk and Water Resources (PEI Report, Volume I).

Stockton on Tees Borough Council Local Plan (2019)

19.2.33 STBC adopted the Local Plan in 2019 with a commitment to contribute towards the national targets on CO_2 reductions by 2050 (STBC, 2019). As part of this plan paragraph 8.5 identifies opportunities in hydrogen and CCS to achieve economic growth and decarbonisation.

Hartlepool Borough Council (HBC)

Hartlepool Local Plan (2019)

19.2.34 HBC's local plan, published in 2019, sets the planning framework for Hartlepool council for the next 15 years (HBC, 2018). Chapter 7 commits to a range of policies related to minimising and adapting to climate change. Policy CC3 encourages the development of renewable and low carbon energy. The local infrastructure plan also commits to ensuring that the replacement of pipelines across Tees Valley will be able to accommodate hydrogen.

<u>Other Guidance</u>

Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment (2013)

19.2.35 This guidance aims to help EU Member States improve the way in which climate change and biodiversity are integrated in Environmental Impact Assessments (EIAs) undertaken across the EU (EU Commission, 2013). Although the UK is no longer a Member State of the EU, this guidance is still considered relevant in the context of EIAs undertaken in respect of developments in the UK.

EC Non-paper Guidelines for Project Managers: Making Vulnerable Investments Climate Resilient (2011)

19.2.36 These guidelines aim to help developers of physical assets and infrastructure incorporate resilience to current climate variability and future climate change within their projects (EU Commission, 2011). Although the UK is no longer a Member State of the EU, this guidance is still considered relevant in the context of EIAs undertaken in respect of developments in the UK.

Guidance for the Calculation of Land Carbon Stocks (2010)

19.2.37 The EU Commission (EU Commission, 2010) provides a calculation methodology for calculating carbon stocks (i.e., CO_2 stored in land or soil habitats), from land use. This guidance is applied in Section 19.3.

British Standards (2019)

19.2.38 The British Standards Institution (BSI) BS EN ISO 14064-1:2019 and 14064-2:2019 (BSI, 2019a; BSI, 2019b) provides specifications for organisational-level and project-level guidance for the quantification and reporting of GHG emissions and removals. These are used within the GHG emissions calculation methodology, as described in Section 19.3.

IEMA Environmental Impact Assessment Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance (2022)

19.2.39 In the absence of any widely accepted guidance on assessing the significance of the impact effect of GHG emissions, guidance published by IEMA (2022) has been followed. This provides a framework for the consideration of GHG in the EIA process, in line with the 2014 EU Directive (EU Directive 2014/52/EU). The guidance sets out how to:

- identify the GHG emission baseline in terms of GHG current and future emissions;
- identify key contributing GHG sources and establish the scope and methodology of the assessment;
- assess the impact of potential GHG emissions and evaluate their significance; and
- consider mitigation in accordance with the hierarchy for managing project related GHG emissions (avoid, reduce, substitute and compensate).

19.2.40 This guidance is used within the GHG emissions calculation methodology, as described in Section 19.3.

IEMA Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation (2020)

19.2.41 The IEMA Guidance for assessing climate change resilience and adaptation in EIA (IEMA, 2022) has been followed. It provides guidance for consideration of the impacts of climate change within project design. The guidance sets out how to:

- define potential climate change concerns and environmental receptors vulnerable to climate factors;
- define the environmental baseline with projections for changing future climate parameters; and
- determine the resilience of project design and define appropriate mitigation measures to increase resilience to climate change.

19.2.42 This guidance is used within the climate change resilience and ICCI methodology, as described in Sections 19.4 and 19.5.

GHG Protocol (2004)

19.2.43 The World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) GHG Protocol provides overarching guidance on developing GHG inventories and reporting standards (World Resource Institute & World Business Council for Sustainable Development, 2004). This guidance is used within the GHG emissions calculation methodology, as described in Section 19.3.

PAS 2080: 2023

19.2.44 Publicly Available Specification (PAS) 2080 specifies whole life carbon management for both buildings and infrastructure. PAS 2080:2023 is an updated revision from the last issue in 2016 and brings an increased emphasis on whole life carbon (BSI, 2023).

2020 UK Greenhouse Gas Emissions, Final Figures (2022)

19.2.45 The 2020 UK Greenhouse Gas Emission, Final Figures (UK Government, 2022) provides the latest estimates of 1990-2015 UK GHG emissions by source and by end user sector.

19.2.46 In 2020, UK emissions of the seven GHGs covered by the Kyoto Protocol were estimated to be 406 million tonnes CO_2 equivalent ($MtCO_2e$). This was 9.5% lower than the 2019 figure.

19.2.47 CO_2 is the main GHG, accounting for 79% of total UK GHG emissions in 2020. The drivers for the decrease in emissions were in the energy supply sector (down 12%), the business sector (4.8%) and the waste management sector (6.7%). The decrease in the energy supply sector is due to the change in the fuel mix for electricity generation, with less use of coal and greater use of nuclear and renewables.

UK Low Carbon Hydrogen Standard (2023)

19.2.48 The UK Low Carbon Hydrogen Standard (Department for Business, Energy and Industrial Strategy, 2023) provides standards to define what constitutes low carbon hydrogen at the point of the production, setting a threshold of 20 gCO_2e/MJ_{LHV} to be considered low carbon. This is to ensure that low carbon hydrogen supported by government makes a direct contribution to the GHG emissions set out in the Climate Change Act.

19.2.49 The methodology sets out the boundaries of calculations e.g., up to the point of production, to be considered when calculating GHG emission from hydrogen.

19.2.50 The requirements around fugitive hydrogen emissions are set in the policy including producing a plan for how hydrogen emissions will be minimised, expected rates of emissions and monitoring plans.

19.2.51 The latest version of the Low Carbon Hydrogen Standard was published in April 2023 following consultation in 2021, with further review expected later in 2023 and for the standard to be updated at regular review points.

19.3 Greenhouse Gas Assessment Methodology and Significance Criteria

Methodology for Determining Baseline Conditions and Sensitive Receptors

Baseline Environment

19.3.1 The baseline environment for the GHG assessment is a '*business as usual'* scenario where the Proposed Development is not undertaken. The baseline comprises existing carbon stock and sources of GHG emissions within the boundary of the Proposed Development Site. The Proposed Development Site covers an area of approximately 1,391 ha.

19.3.2 For the purposes of determining net changes in GHG emissions as a consequence of the Proposed Development, it is assumed that there are no activities on the Proposed Development Site currently and that the area is fully under hardstanding. The baseline emissions were considered to be zero and all project emissions were considered as additional.

19.3.3 The methodology for calculating GHG emissions and removals has been consistently used across the baseline, construction and operational phases of the Proposed Development, as described below.

19.3.4 The GHG baseline also considers the impact of grid electricity generation where the Proposed Development is not built.

Project Environment

19.3.5 The alternative environment to the 'business as usual' in which the Proposed Development is not undertaken is a 'do something' scenario with the delivery of the Proposed Development, which includes its construction, operation and decommissioning.

Study Area

19.3.6 The Study Area for the lifecycle GHG impact assessment considered direct GHG emissions arising from activities within the Proposed Development boundary and indirect emissions from activities outside of the Proposed Development Site but related to the construction, operation and decommissioning of the Proposed Development (for example, the transportation of materials and embodied carbon within construction materials). As it is not known where constructional materials will be sourced from at this stage, the Study Area for indirect emissions was assumed to be global.

Sensitive Receptors

19.3.7 The identified receptor for GHG emissions is the global climate as effects are not geographically constrained which means that all development has the potential to result in a cumulative effect on GHG emissions. Therefore, for the purpose of the GHG emissions impact assessment, the global climate was used as the sensitive receptor. The UK's relevant five-year carbon budget will be used as a proxy for the global climate.

Cumulative Assessment

19.3.8 In line with IEMA guidance, a Cumulative Assessment is not considered appropriate or meaningful in terms of assessing the Proposed Developments impact on the receptor of the global climate.

19.3.9 IEMA guidance states that *"All global cumulative GHG sources are relevant to the effect on climate change, and this should be taken into account in defining the receptor (the atmospheric concentration of GHGs) as being of 'high' sensitivity to further emissions."*

19.3.10 In essence, there is no difference in the impact on the global climate of a tonne of CO_2e emitted at one location compared to the same mass of CO_2e emitted anywhere else on the planet. So, it is not meaningful to carry out a cumulative assessment of the Proposed Development alongside other developments in a geographical area, nor is such an exercise reasonably practicable due to the difficulties in accessing reliable future emissions data for other developments.

19.3.11 The GHG assessment is considered inherently cumulative as all GHG emissions have the potential to equally impact the receptor i.e. the global climate. UK Carbon budgets, setting binding limits on the total emissions that can be emitted in the UK, are used as a proxy for the global climate for the GHG assessment.

Rochdale Envelope

19.3.12 A focused use of the Rochdale Envelope approach has been adopted to present a worst-case assessment of potential environmental effects of the different parameters of the Proposed Development that cannot yet be fixed. The Rochdale Envelope approach has specifically been used to estimate likely emissions from construction, upstream operational emissions and operational chemicals used.

Impact Assessment Methodology

19.3.13 The assessment has adopted a project lifecycle approach to identify 'hot spots' of GHG emissions (i.e., the project stage(s) likely to generate the largest amount of GHG emissions) and enable priority areas for mitigation to be identified. This approach is consistent with the principles set out in IEMA guidance (IEMA, 2022) and PAS 2080 (BSI, 2023).

19.3.14 In line with the WRI and WBCSD GHG Protocol guidelines (World Resource Institute & World Business Council for Sustainable Development, 2004) the lifecycle GHG impact assessment has been reported as tonnes of CO_2 equivalent (tCO_2e) and has considered the seven Kyoto Protocol gases:

- CO_2;
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Sulphur hexafluoride (SF_6);
- Hydrofluorocarbons (HFCs);

- Perfluorocarbons (PFCs); and
- Nitrogen Trifluoride (NF_3).

19.3.15 Where data is available, GHG emissions arising from construction activities, embodied carbon in materials and operational emissions of the Proposed Development have been quantified using a calculation-based methodology as per the following equation and aligned with the GHG Protocol (World Resource Institute & World Business Council for Sustainable Development, 2004):

Activity data x GHG emissions factor = GHG emissions

19.3.16 A set of standard data quality principles have been applied so that the results from the GHG assessment are as accurate and representative as possible. This has included the selection of emission factors that are representative of the UK construction industry.

19.3.17 The Department for Energy Security and Net Zero (ESNZ) 2022 emissions factors (ESNZ, 2023) and embodied carbon data from the Inventory of Carbon and Energy V3.0 (ICE, 2019) have been used as the main sources of emissions factors for calculating GHG emissions. The resulting carbon footprint has been compared to the existing baseline condition to identify the impact of the Proposed Development.

Methodology for Determining Demolition, Construction and Operation Effects

19.3.18 Where relevant GHG activity data is unavailable, assumptions and estimations have been developed based on similar developments, industry benchmarks and professional judgement. Any assumptions, inclusions and exclusions that inform the GHG emissions calculation have been clearly described in the sections below.

19.3.19 In order to assess the potential impacts of GHG emissions arising from the Proposed Development, likely activities and their associated GHG emissions sources have been estimated. Potential activities related to the Proposed Development that could cause GHG emission impacts are presented in Table 19-1.

Table 19-1: GHG Emission Sources

LIFECYCLE STAGE	ACTIVITY	PRIMARY EMISSION SOURCES
Pre-construction (including demolition)	On-site pre-construction activity i.e., enabling works etc. (not including Teesworks preparation works which would take place prior to commencement of the Proposed Development)	GHG emissions from fuel consumption by construction plant and vehicles, generators on-site, and worker commuting.
	Transportation and disposal of earthworks/ waste	GHG emissions from transportation and disposal of earthworks/pre-construction waste.

LIFECYCLE STAGE	ACTIVITY	PRIMARY EMISSION SOURCES
	Land clearance	GHG emissions associated with the loss of carbon stock.
Product manufacture	Raw material extraction and manufacturing of products/materials	Embodied GHG emissions associated with product and material manufacture.
	Transport of products/ materials to site	GHG emissions from fuel consumption of transportation of products and materials to site.
Construction	On-site construction activity	Energy (electricity, fuel etc.) consumption from plant and vehicles, generators on-site, and material consumption.
	Transport of construction workers	Energy (electricity, fuel etc.) consumption from worker commuting.
	Transportation and disposal of earthworks/ waste	GHG emissions from transportation and disposal/treatment of earthworks/ construction waste.
Operations	Operation of the Proposed Development	GHG emissions from energy use, fugitive emissions of gases including carbon and hydrogen, natural gas supply and additional traffic.
	Transportation and disposal of waste	GHG emissions from transportation and disposal of waste.
	Building and grounds maintenance (out of scope)	GHG emissions associated with replacement materials/products.
	Emissions displacement	Avoided or displaced emissions through use of hydrogen or offsetting.
	Landscaping	Changes in GHG emissions/sinks from landscaping and re-vegetation.

LIFECYCLE STAGE	ACTIVITY	PRIMARY EMISSION SOURCES
Decommissioning	Removal and or renewal of the Proposed Development	GHG emissions arising from fuel consumption for plant and vehicles and disposal of materials.

Classification and Significance of Effects

Significance Criteria

19.3.20 IEMA (2022) guidance states that there are currently no agreed methods to evaluate levels of GHG significance and that professional judgement is required to contextualise a proposed development's emission impacts.

19.3.21 In GHG accounting, it is considered good practice to contextualise emissions against pre-determined carbon budgets (IEMA, 2022). The Tees Valley targets noted in Plate 19-1 do not have a statutory or policy requirement to be considered so the UK Carbon Budgets are used to contextualise the level of significance.

19.3.22 There is currently no published standard definition for receptor sensitivity of GHG emissions. As per IEMA (2022) guidance, all GHG emissions were classed as having the potential to be significant as all emissions contribute to climate change. The global climate has been identified as the receptor for the purposes of the GHG assessment. The sensitivity of the climate to GHG emissions was considered to be 'High'. The rationale supporting this includes:

- Any additional GHG impacts could compromise the UK's ability to reduce its GHG emissions and therefore the ability to meet its future carbon budgets.
- The importance of meeting the Paris Agreement goal of limiting global average temperature increase to well below 2°C above pre-industrial levels (paragraph 21.2.4). Additionally, a recent report by the Intergovernmental Panel on Climate Change (IPCC) highlighted the importance of limiting global warming below 1.5°C (IPCC, 2023)

19.3.23 Table 19-2 summarises IEMA guidance on how to apply significance criteria for GHG impact of projects.

Table 19-2: IEMA Significance Criteria

LEVEL OF EFFECT	SIGNIFICANCE CRITERIA	SIGNIFICANCE
Major Adverse	The project's GHG impacts are not mitigated or are only compliant with do-minimum standards set through regulation, and do not provide further reductions required by existing local and national policy for projects of this type. A project with major adverse effects is locking in emissions and does not make a meaningful	Significant

LEVEL OF EFFECT	SIGNIFICANCE CRITERIA	SIGNIFICANCE
	contribution to the UK's trajectory towards net zero.	
Moderate Adverse	The project's GHG impacts are partially mitigated and may partially meet the applicable existing and emerging policy requirements but would not fully contribute to decarbonisation in line with local and national policy goals for projects of this type. A project with moderate adverse effects falls short of fully contributing to the UK's trajectory towards net zero.	Significant
Minor Adverse	The projects GHG impacts would be fully consistent with applicable existing and emerging policy requirements and good practice design standards for projects of this type. A project with minor adverse effects is fully in line with measures necessary to achieve the UK's trajectory towards net zero.	Not Significant
Negligible	The projects GHG impacts would be reduced through measures that go well beyond existing and emerging policy and design standards for projects of this type, such that radical decarbonisation or net zero achieved well before 2050. A project with negligible effects provides GHG performance that is well 'ahead of the curve' for the trajectory towards net zero and has minimal residual emissions.	Not Significant
Beneficial	The project's net GHG impacts are below zero and it causes a reduction in atmospheric concentration, whether directly or indirectly compared to the without project baseline. A project with beneficial effects substantially exceeds net zero requirements with a positive climate impact.	Significant

19.3.24 To comply with the UK Government's low carbon hydrogen standard, hydrogen must be able to be produced at an intensity of $20gCO_{2e}/MJ_{LHV}$ or less (Department for Business, Energy and Industrial Strategy, 2023). The accounting boundary for this does not include construction, or downstream transmission and leakage emissions. The GHG assessment has been carried out both as a whole-life assessment, and compared against the boundary of the UK low carbon hydrogen standard.

19.3.25 The boundaries of the low carbon hydrogen standard are not whole life carbon as they do not include construction or any downstream combustion emissions. Where the overall emissions of the development were compared against the $20gCO_{2e}/MJ_{LHV}$ standard the boundaries align with the scope of the standard. Elsewhere total emissions were calculated across a whole life carbon scope.

19.3.26 The significance criteria compare emissions from the Proposed Development against the baseline within the Proposed Development Site i.e. no operational activity. In this context the Proposed Development will have GHG emissions.

19.3.27 When viewed in a wider context the fuel from the Proposed Development will have a role in displacing different fuel and energy sources. Therefore, a broader approach to significance has been taken, looking at the reductions and mitigations associated with introducing hydrogen into the UK fuel supply over time.

UK Carbon Budgets

19.3.28 The UK carbon budgets, shown in Table 19-3, are in place to restrict the volume of GHG emissions the UK can legally emit in a five-year period (UK Government, 2023). The UK is currently in the 4th carbon budget period which runs from 2023 to 2027. The 3rd to the 5th carbon budgets reflect the earlier UK target (80% reduction target by 2050). The 6th carbon budget, (Climate Change Committee, 2020), is the first budget to reflect the amended net zero target. As the Proposed Development will be active past 2050, the assessment also compared the emissions against the net zero by 2050 target.

Table 19-3: Current UK Carbon Budgets

UK CARBON BUDGET (PERIOD)	TOTAL BUDGET ($MTCO_2E$)	INDICATIVE CARBON BUDGETS BASED ON CCC'S NET-ZERO PATHWAY ($MTCO_2E$)
4th (2023-2027)	1,950	-
5th (2028-2032)	1,725	-
6th (2033- 2037)	965	-
7th (2038-2042)	-	526
8th (2043-2047)	-	195
9th (2048-2050)	-	17

Determining Construction Effects

19.3.29 Due to unavailability of construction data in terms of quantities of materials or design, benchmark values for industrial construction projects have been used to estimate the embodied carbon associated with construction of the Proposed Development. The included emissions are summarised in Table 19-4.

19.3.30 There is the potential that landfill sites may be affected or disturbed by underground construction, leading to GHG emissions from the Proposed Development Site. It was not possible to currently quantify the potential emissions from this, though they can be avoided through mitigation actions where possible.

19.3.31 As detailed in Chapter 5: Construction Programme and Management (PEI Report, Volume I), site preparation and remedial works at the Main Site would be completed by Teesworks prior to the commencement of construction of the Proposed Development. Teesworks would obtain the necessary consents and permits to do this work; as such they are not considered in this assessment. The proposed remediation works will be subject to further review following the assessment of ground condition information. Further remedial measures may be required during the construction phase of the Proposed Development. These would be localised, targeted remediation works. As such, these works are considered and assessed, along with site construction activities including management and movement of previously remediated material, as detailed in Table 19-4 below.

Table 19-4: Scope of Potential GHG Emission Sources from the Construction Stage

LIFECYCLE STAGE	ACTIVITY	PRIMARY EMISSION SOURCES	SCOPED IN/ OUT
Enabling Works	Any enabling works (excluding Teesworks preparatory works)	GHG emissions from any activities required onsite prior to construction including targeted excavation activities of previously remediated material for the purpose of the installation of the foundations.	In
	Land clearance	Loss of carbon sink.	In
Production Stage	Raw material extraction and manufacturing of products/materials. Transport of products/materials to site.	Embodied GHG emissions. GHG emissions from fuel consumption for transportation of materials.	In
Construction process stage	On-site construction activity Transport of construction workers	Energy (electricity, fuel etc.) consumption from plant and vehicles, generators on site and construction workers commuting. GHG emissions from fuel consumption for transportation of construction workers.	In

LIFECYCLE STAGE	ACTIVITY	PRIMARY EMISSION SOURCES	SCOPED IN/ OUT
	Transportation and disposal of construction waste	GHG emissions from energy use and from fuel consumption for transportation of waste.	In
	Provision and treatment of water	GHG emissions from the supply of potable water, and the disposal and treatment of wastewater.	In

Determining Operational Effects

19.3.32 The methodology for determining Proposed Development operational GHG emissions was the same as that for the enabling works, production stage and construction process stage emissions. Table 19-5 summarises the key anticipated GHG emissions sources and whether they have been scoped in or out of the assessment. There are a range of uncertainties associated with fugitive hydrogen, carbon capture, and Global Warming Potential (GWP) values which are discussed in paragraphs 19.3.77-19.3.80.

19.3.33 Maintenance and repair have been scoped out due to its low contribution to the overall footprint. Whole Life Carbon assessment methodology often recommends setting usage and maintenance emissions at 1% of the embodied construction emissions for the building and based on the construction emissions having a relatively small contribution to the life cycle this was considered to be immaterial to the footprint (Greater London Authority, 2022).

19.3.34 There is currently no information available for the quantities of amines and other chemicals required for the carbon capture process, but this is expected to be immaterial to the overall footprint and less than 1% of total emissions as it is a closed loop system for amines so raw material procurement should be minimal.

Table 19-5: Scope of Potential GHG Emission Sources from the Operational Stage

LIFECYCLE STAGE	ACTIVITY	PRIMARY EMISSION SOURCES	SCOPED IN/ OUT
Operation	Operation of the Proposed Development	GHG emissions from flare, methane extraction and well to tank, electricity for plant, CO_2 atmospheric emission not captured, and any other materials required for operation of plant.	In
	Use of vehicles i.e., cars and motorcycles	GHG emissions from vehicle use from worker journeys to and from the site.	In

LIFECYCLE STAGE	ACTIVITY	PRIMARY EMISSION SOURCES	SCOPED IN/ OUT
	Disposal and transportation of operational waste	GHG emissions from recycling/ disposal of process waste and domestic waste. GHG emissions from fuel consumption for transportation of raw materials and waste.	In
	Provision and treatment of water	GHG emissions from the supply of potable water, and the disposal and treatment of wastewater.	In
	Combustion of Hydrogen Product	GHG emissions from combustion of residual methane in Hydrogen Stream	In
	Building/ infrastructure maintenance	GHG emissions from maintenance of buildings and infrastructure/assets in the operational stage.	Out

Determining Decommissioning Effects

19.3.35 The methodology for determining Proposed Development decommissioning GHG emissions is the same as for that for the enabling works, production stage, construction process stage and operational emissions. Table 19-6 summarises the key anticipated emissions sources and whether they were scoped in or out of the assessment.

19.3.36 Due to the high uncertainty around decommissioning emissions, resulting from the long life-cycle of the Proposed Development and the anticipated decarbonisation of technologies associated with decommissioning, it was not possible to do a quantitative assessment.

Table 19-6: Scope of Potential GHG Emissions Sources from the Decommissioning Stage

LIFECYCLE STAGE	ACTIVITY	PRIMARY EMISSION SOURCES	SCOPED IN/OUT
Decommissioning	Raw material extraction and manufacturing of products/materials. Transport of products/materials to site.	Embodied GHG emissions. GHG emissions from fuel consumption for transportation of materials.	In

LIFECYCLE STAGE	ACTIVITY	PRIMARY EMISSION SOURCES	SCOPED IN/OUT
	On-site decommissioning activity. Transport of decommissioning workers	Energy (electricity, fuel etc.) consumption from plant and vehicles, generators on site, and workers commuting. GHG emissions from fuel consumption for transportation of workers.	In
	Transportation and disposal of waste	GHG emissions from energy use and from fuel consumption for transportation of waste.	In
	Provision and treatment of water	GHG emissions from the supply of potable water, and the disposal and treatment of wastewater.	In

Consultation

19.3.37 The Scoping Opinion was provided on 17th May 2023 by the Planning Inspectorate ('the Inspectorate'). A high-level summary of responses to the Scoping Opinion comments of relevance to this assessment are outlined in Table 19-7.

Table 19-7: Responses to Scoping Comments

CONSULTEE	DATE AND METHOD OF CONSULTATION	SUMMARY OF CONSULTEE COMMENTS	SUMMARY OF RESPONSE/ HOW COMMENTS HAVE BEEN ADDRESSED
The Planning Inspectorate ('the Inspectorate')	Scoping Opinion 17th May 2023	GHG emissions arising from disturbance of landfill sites Figure 10 of the Scoping Report shows that there are active and historic landfill sites present within the Proposed Development Site. There is a potential that underground construction works could lead to GHG emission from these sites that should be included in the assessment.	The PEI Report acknowledges the potential for GHG emissions from disturbing landfill sites in paragraph 19.3.30 This will be further considered in the Environmental Statement (ES).
The Inspectorate	Scoping Opinion 17th May 2023	Carbon Capture The scoping report states that CO_2 will be captured at a rate of 95%, secured through an environmental permit. Should the draft DCO allow for generating station to operate independently of carbon capture a worst-case assessment of emissions should be undertaken.	It is a fundamental assumption of the project that CO_2 will be captured. This has been emphasised in paragraph 19.3.60. An assessment of the impact without carbon capture has been made in response to this request in paragraph 19.3.73.
The Inspectorate	Scoping Opinion 17th May 2023	CO_2 Emissions The CO_2 generated from the Proposed Development is proposed to be exported via the proposed NZT project and to the proposed NEP offshore storage. The ES should describe the status of these projects and any uncertainty around this method of exportation and/or alternative proposals. Please refer to the Inspectorate's comments at ID 2.1.3 of this Scoping Opinion regarding assessment of CO_2 emissions should the DCO seek or allow for powers for	It is a fundamental assumption of the project that CO_2 will be captured. This has been emphasised in paragraph 19.3.60. An assessment of the impact without carbon capture has been made in response to this request, in paragraph 19.3.73.

CONSULTEE	DATE AND METHOD OF CONSULTATION	SUMMARY OF CONSULTEE COMMENTS	SUMMARY OF RESPONSE/ HOW COMMENTS HAVE BEEN ADDRESSED
		the generating station component to operate independently of the carbon capture.	
The Inspectorate	Scoping Opinion 17th May 2023	CH_4 The ES should include consideration of CH_4 emissions as part of the GHG assessment or otherwise demonstrate why the emissions are so small so as not to result in likely significant effects. The ES should describe any mitigation required in respect of CH_4 emissions and confirm how this would be secured in the DCO.	CH_4 emissions are considered in Table 19-5 of this chapter, where the well-to-tank emission factor used for CH_4 supply is processed into hydrogen as the first step. CH_4 leakage is accounted for in the ESNZ well-to-tank emission factors used (Exergia, 2015; ESNZ, 2023). This has been clarified in the assumptions in paragraph 19.3.6060.

<u>GHG Impact Avoidance Measures</u>

Construction

19.3.38 The Proposed Development is being designed, as far as possible, to avoid and minimise impacts and effects through the process of design development, and by embedding mitigation measures into the design. One of the key drivers for the Proposed Development is to assist the UK in meeting its net zero targets through the production and distribution of hydrogen to help decarbonise the transportation sector and to help facilitate the use of carbon capture and storage.

19.3.39 During construction GHG emissions will be managed through a Construction Environmental Management Plan (CEMP) and related plans including a Site Waste Management Plan (SWMP). The CEMP will control construction activities to minimise any impact on the environment through relevant regulations, industry good practice and specific measures, including those described in this PEI Report and the Environmental Statement (ES).

19.3.40 A Framework CEMP will be included within the ES which will accompany the DCO Application. A Final CEMP will be prepared by the construction contractor in accordance with the Framework CEMP prior to construction. The submission, approval, and implementation of the Final CEMP will be secured by a Requirement of the draft DCO.

19.3.41 The CEMP will require that the appointed contractors develop and implement processes to measure, monitor and report energy and water consumption and GHG emissions during Proposed Development construction. Examples include, but are not limited to:

- fuel consumption on site in vehicles, equipment and plant through minimisation of idling, and switching off when not being used;
- reduction in water consumption in the on-site amenity blocks and construction activities (including dampening down as part of dust mitigation);
- minimisation of transportation of materials to the site, by implementing measures set out in the Framework CTMP that will be included within the ES;
- minimisation of emissions through worker commuting by encouraging group transport by the provision of minibuses pursuant to a Framework CTMP that will be included within the ES;
- provision of facilities for cyclists pursuant to a Framework CTMP that will be included within the ES;
- provision of information on public transport links pursuant to a Framework CTMP that will be included within the ES; and
- setting minimum rates for material recycling and re-use.

Operation

19.3.42 The main mitigation strategy is carbon capture which is designed to capture in excess of 95% of the emissions resulting from the Proposed Development operation. It is a key assumption that carbon capture is part of the Proposed Development and transported and stored using NEP infrastructure.

19.3.43 When comparing emissions against the low carbon hydrogen standard, it is assumed that all CO_2 injected into the network is stored and that there is zero leakage in the CO_2 network and storage sites. This is in alignment with the standard which states "*For the purposes of hydrogen emissions reporting under the standard, it is assumed that once CO2 is injected into the CO2 network, and the liability for the CO2 is transferred between parties, there is zero leakage in the CO2 network and storage sites.*"

19.3.44 For the Whole Life Carbon assessment, a small amount of leakage of CO2 from the network is expected, but likely to be insignificant in the overall assessment.

19.3.45 Process emissions, mainly CO_2, H_2 and CH_4, would be managed and regulated through an Environmental Permit by the Environment Agency in accordance with the Environmental Permitting (England and Wales) Regulations 2016.

19.3.46 The permit application will present a number of measures that the Proposed Development will include in order to improve energy efficiency and to reduce overall GHG emissions.

19.3.47 In addition, the Proposed Development will be operated in line with appropriate standards, whilst the operator will implement and maintain an Environment Management System (EMS) which will be certified to International Standards Organisation (ISO) 14001.

19.3.48 Other embedded measures incorporated in the operational design will be outlined in the ES when the Proposed Development design is more progressed.

19.3.49 Additional maintenance and mitigation measures could include the following and appropriate measures will be developed and assessed further and included in the ES as relevant:

- minimising flaring and venting of gases in operation
- minimising leakage of hydrogen and using trace systems;
- minimising of CO_2 and CH_4 leakage in connection corridors;
- use of energy efficient lighting; and
- optimisation of overall auto thermal reforming process.

Decommissioning

19.3.50 At this stage, limited specific additional mitigation measures have been identified for the Proposed Development decommissioning phase due to uncertainties in the activities that will be undertaken, future emission factors and technologies available. A Decommissioning Environmental Management Plan (DEMP) would be produced pursuant to a DCO Requirement, in accordance with guidance and legislation at the time and would likely include measures to reduce GHG emissions (for example encouraging the contractors to recycle the bulk of the plant, equipment and materials).

Likely Impacts and Effects

Description of Potential Effects

19.3.51 This section presents preliminary findings of the GHG impact assessment for the construction (including commissioning), operation and decommissioning of the Proposed Development. It identifies any likely significant effects that are predicted to occur and then highlights the mitigation and enhancement measures that are proposed to minimise any potential adverse significant effects.

Construction

19.3.52 Construction emissions were calculated using data about vehicle movements and quantities of key construction materials required for the Proposed Development. Total emissions are summarised in Table 19-8.

19.3.53 The main materials are aggregates for earthworks and backfill, concrete for foundations and piles, steel for structural reinforcement, pipework and asphalt for roads. Total quantities were multiplied by emission factors from the ICE database (ICE, 2019).

19.3.54 Transport of materials is assumed to be a 50km return trip by Heavy Goods Vehicle (HGV), using the ESNZ emission factor for an average laden HGV journey of 0.8539 $kgCO_2e/km$ (ESNZ, 2023). There are expected to be approximately 50,550 HGV journeys associated with the Proposed Development.

19.3.55 Transport of workers is assumed based on a weighted average of 19.2km based upon distribution of permanent workers detailed in Traffic and Transport, Table 15-20. A return journey is calculated using the ESNZ emission factor for an average unknown car journey of 0.20874 $kgCO_2e/km$. There are 259,020 journeys during construction.

19.3.56 5% of construction materials are assumed to go to waste and emissions are calculated using the landfill-based emission factors from ESNZ (2023).

19.3.57 Detailed data is not currently available for plant operation energy and fuel consumption however this is considered to be relatively immaterial and will not impact the overall significance of the Proposed Development’s emissions. Detailed construction data will be updated during the EIA.

19.3.58 As outlined in Chapter 5: Construction and Programme Management (PEI Report, Volume I) construction of Phase 1 is due to be completed in 2028, with Phase 2 commencing in 2028 for a further 3 years, with construction to be completed by late 2030.

Table 19-8: Construction Emissions

LIFECYCLE STAGE	ACTIVITY/EMISSION SOURCE	EMISSIONS (TCO_2E)
Raw Materials (A1-3)	Concrete, aggregate, steel and asphalt for construction	20,944
Transport of Materials (A4)	50km return HGV trip transport for construction materials	4,317
Transport of workers (A5)	Return trip via car for workers	2,074
Waste (A5)	Disposal of 5% of raw materials at landfill, disposal of hazardous and non-hazardous waste from site preparation.	550
TOTAL	27,885	
Annual estimation over 4-year Period[1]	6,971	

19.3.59 A further assessment will be carried out and reported in the ES which will provide a breakdown of relevant construction activities such as worker commuting, transport of materials, fuel and electricity use.

Operation

19.3.60 There are a range of uncertainties with future operation that are discussed in 19.3.77 to 19.3.80. To assess the magnitude of climate change impacts associated with operating the Proposed Development, the GHG emissions that are associated with relevant activities were calculated based on the assumptions listed below:

- the Proposed Development is expected to be available and manned 24 hours a day, 7 days per week for 28 years (25 years from completion of phase 2). With regard to maintenance schedules, it is assumed that any outages are brief, so a fully operational plant is assumed at 8,760 hours per year;
- the majority of the emissions arise from a scenario of 5% unabated CO_2 from the Hydrogen Production Facility, upstream CH_4 emissions and downstream combustion of residual CH_4 in H_2 stream. More minor contributions come from processing CO_2 flue gases from the fired heater and vent, imported electricity and worker transport;
- there is currently no information available for the quantities of amines and other chemicals required for the carbon capture process, but this is expected to be immaterial to the overall footprint;

[1] Four years used as worst case to give highest annual emissions.

- all residual CH_4 in the hydrogen output product is combusted and converted to CO_2 and water;
- natural gas used for the start-up of the fired heater is not considered in the analysis - further details will be provided in the ES;
- staff levels are expected to be the same in Phases 1 and 2;
- electricity demand, hydrogen output, CO_2 streams and Scope 3 emissions double in scale after Phase 2;
- the Proposed Development is designed to capture in excess of 95% of the carbon, as required by UK government for hydrogen;
- electricity-related emissions have been calculated using ESNZ projections for grid intensity to 2100 (ESNZ, 2023); and
- natural gas leakage on site is relatively low due to the first process of the Auto Thermal Reformer (ATR) splitting natural gas. Therefore, natural gas leakages are only accounted for in upstream emissions calculations.

19.3.61 The key activity data for the emissions assessment is provided in Table 19-9. The resulting calculated emissions based on the data presented Table 19-9 are shown in Table 19-10 and Table 19-11. These emissions were categorised in line Scopes 1, 2 and 3 in line with the GHG protocol. Scope 1 covers direct emissions from controlled sources such as on-site combustion, whilst scope 2 covers indirect emissions from purchase of electricity, steam, heating and cooling. Scope 3 emissions are a consequence of activities of the company from sources not owned or controlled by the company.

19.3.62 The unabated CO_2 emissions in Table 19-9 were back-calculated based upon the quantity of CO_2 captured in the process. The natural gas demand was back-calculated based on the emissions listed in the report and the emission factor used, to identify the raw natural gas demand.

19.3.63 Downstream CH_4 combustion emissions arise from the anticipated residual CH_4 in the hydrogen export steam. When combusted this is assumed to convert to CO_2.

Table 19-9: Activity Data from Phase 1

ITEM	ACTIVITY	VALUE
Scope 1	Flare, gas, flue, vent and seal leakage	497 $kgCO_2e$/hour
	Uncaptured CO_2 emissions (5% that is not captured at 95% capture rate)	8216.8 $kgCO_2e$/hour
Scope 2	Electricity demand	33,925 kW
Scope 3	Natural Gas demand	64,074 kg/hour

ITEM	ACTIVITY	VALUE
	Downstream residual methane combustion emissions	2,127 $kgCO_2e$/hour
	Regular workers	50 Staff
	Irregular maintenance workers	400 people over a 7 day period every 4 years

19.3.64 The flare gas, flue vent and seal leakages, unabated CO_2 emissions and downstream CH_4 combustion emissions are already in kgCO2e/year, so were multiplied by the operational hours per year to calculate emissions in Table 19-10 and Table 19-11.

19.3.65 Imported electricity from the grid will decarbonise throughout the life of the project, and this is calculated using projections from ESNZ projections (2023). The figures in Table 19-10 and Table 19-11 represent the average grid emissions per year across the different phase timescales.

19.3.66 Upstream CH_4 emissions were calculated using the ESNZ well-to-tank factor of 0.423 $kgCO_2e$/kg for natural gas which represents the upstream emissions from sourcing and extracting natural gas (Exergia, 2015; ESNZ, 2023). This emission factor also accounts for leakage in the upstream natural gas sourcing (Exergia, 2015).

19.3.67 Worker transport was calculated using the same assumptions and emission factors as construction emissions, detailed in paragraph 19.3.55.

Table 19-10: Average Annual GHG Emissions from Phase 1

ITEM	ACTIVITY/EMISSION SOURCE	EMISSIONS (TCO_2E/YEAR)
Scope 1	Flue gases, flare, vent gases and seal leakage	4,356.7
	Uncaptured CO_2 emissions (5% that is not captured at 95% capture rate)	72,028.6
Scope 2	Imported electricity (average of 2028-2029)	32,772.6
Scope 3	Upstream emissions (well to tank methane extraction)	237,679.8
	Downstream emissions (combustion of methane in output hydrogen product)	18,645.3
	Worker transport	172.7
TOTAL		365,655.6

Table 19-11: Average Annual GHG Emissions from Phase 2

ITEM	ACTIVITY/EMISSION SOURCE	EMISSIONS (TCO_2E/YEAR)
Scope 1	Flue gases, flare, vent gases and seal leakage	8713.4
	Uncaptured CO_2 emissions (5% that is not captured at 95% capture rate)	144,057.3
Scope 2	Imported electricity (average of 2030-2055)	14,209.1
Scope 3	Upstream emissions (well to tank methane extraction)	475,359.5
	Downstream emissions (combustion of methane in output hydrogen product)	37,290.6
	Worker transport	172.7
TOTAL		679,802.5

19.3.68 Over 28 years (25 years from completion of phase 2) the overall GHG emissions from Proposed Development operation add up to 16,404,094 tCO_2e.

19.3.69 The Proposed Development has an output of 22,175kg/hour of hydrogen in phase 1, which scales up to 44,350kg/hour in phase 2. The output stream has an energy content of 97,407 kJ/kg, or 27.06 kWh/kg. This gives an energy output of 252,461 GWh over 28 years (25 years from completion of phase 2).

19.3.70 Dividing the emissions in scope of the low carbon hydrogen standard, not including downstream combustion of residual CH_4 in the hydrogen stream and construction emissions, by the energy produced gives an emission factor of 17.0 gCO_2e/MJ compared to the low carbon standard of 20 gCO_2e/MJ_{HV} (Department for Business, Energy and Industrial Strategy, 2023).

19.3.71 The whole life carbon emissions of the Proposed Development, including downstream and construction emissions, have an emission factor of 65.0 gCO_2e/kWh represents a 72% reduction against the emissions associated with the whole life carbon emissions of natural gas (236.14 gCO_2e/kWh including combustion and well to tank).

19.3.72 This would add to an abatement of 43.2 $MtCO_2e$ over the life cycle of the project, as a result of replacing natural gas with hydrogen on a per kWh basis. It should be noted that this does constitute a higher footprint per kWh than electricity beyond 2029, which means that the benefits of the hydrogen product differ if used to displace other fuels such as coal or diesel. Its benefit would be maximised in 'hard-to-electrify' sectors.

19.3.73 If the DCO were to seek powers for generating hydrogen independently of carbon capture, effectively a carbon capture rate of 0%, the life cycle emissions would add up to 82,094,21 tCO_2e, equivalent to 111 gCO_2e/Mj compared to the low carbon standard of 20 gCO_2e/MJ. The overall emission factor of 405 gCO_2e/kWh represents a 71 % increase against the emissions associated with natural gas. Therefore, it is an assumption of the Proposed Development that 95% carbon capture will be achieved, secured via the environmental permit.

Decommissioning

19.3.74 In order to assess the magnitude of the climate change impacts through GHG emissions associated with Proposed Development decommissioning, the GHG emissions that would be associated with decommissioning activities include those associated with:

- demolition and excavation of all buildings and infrastructure, as required;
- Blowdown/venting of natural gas lines
- disposal and treatment of wastes; and
- return of the Proposed Development Site to an industrial brownfield use under hardstanding (i.e. no change in land use).

19.3.75 The Proposed Development has a long design life and as such it is not considered possible to reliably forecast decommissioning requirements and infrastructure far in the future. The decommissioning phase is anticipated to involve the removal of all above surface structures. It is assumed that all underground infrastructure would remain in-situ; however, all connection and access points would be sealed or grouted to ensure disconnection.

19.3.76 As the main processes associated with decommissioning are likely to be decarbonised by the end of the life-cycle of the plant, the emissions from decommissioning are expected to be minimal. To comply with the UK government's net zero commission, any decommissioning after 2050 would have to be net zero. For this reason it is not possible to provide a quantitative assessment of the decommissioning GHG emissions, but they are expected to be low in relation to Proposed Development construction and operation.

Uncertainty in Impact Analysis

Hydrogen Fugitive Emission

19.3.77 Hydrogen is not a recognised GHG, but has an indirect effect on the climate due to its effect on hydroxyl radicals leading to lengthening the atmospheric lifetime of CH_4 (Warwick, et al., 2022). The global warming effect of Hydrogen is still uncertain (Warwick, et al., 2022), therefore it has not been accounted for in the GHG assessment. There is a potential that fugitive emissions of Hydrogen could contribute to the impact of the Proposed Development though, so in line with the low carbon hydrogen standard the Proposed Development will minimise cold venting and fugitive emissions of Hydrogen throughout the operation.

Short Lived GHG Gases

19.3.78 CH_4 and hydrogen are both gases that break down relatively quickly in the atmosphere, compared to the 100-year timespan used for global warming analyses. GWP is a measure used to compare non-CO_2 gases that have a global warming effect to CO_2. In this CO_2 has a GWP of 1, so if a theoretical gas has a GWP of 2 then it has twice the warming effect over the selected timespan. This means that the effect of fugitive emissions are far higher if considered on a shorter time horizon such as 20 years. The IPCC estimates CH_4 to have a GWP of 56 as opposed to 21 (IPCC, 2023), while a UK Government study suggests hydrogen would have a GWP of 33 instead of 11 (Warwick, et al., 2022). This suggests that the risks of large increases in hydrogen emissions, from factory leakage, and CH_4 leakage from upstream extraction, may be far higher when considered in the 20-year time horizon to 2050. A key difference between these and CO_2 however is that the short term lifespan means that the global warming effect is more related to the rate of change of emissions i.e. if CH_4 emissions stay constant for 13 years (the atmospheric lifespan of CH_4) then there would not be any increased global warming effect (Allen, et al., 2018). CH_4 emissions are not likely to increase with the Proposed Development, however, as the CH_4 used comes from an existing connection and the resulting Hydrogen will likely serve the surrounding industrial cluster displacing natural gas. With hydrogen having a short lifespan of 2 years, and the Proposed Development reaching a relatively steady state of production after 2 years of phase 2, it is possible that there would not be any additional global warming effects from hydrogen leakage after the initial 2 years of phase 2 operation.

Effects from GHG Transport and Storage Network

19.3.79 As the carbon capture depends on a transport and storage network from the Net Zero Teesside (NZT) development, consideration needs to be given to construction and operational emissions from the network. The offshore construction, operation and decommissioning emissions from the network combine to 357,408 tCO_2e. The offshore element will provide CO_2 transport and storage capacity for multiple industrial emitters in the cluster, including NZT and H2 Teesside. As there are multiple users this 357,408 tCO_2e is not accounted for in the overall emissions. In the context of the overall construction emissions and long-term operation emissions of the development this is unlikely to affect the significance of the Proposed Development.

Natural Gas Leakage and Decarbonisation

19.3.80 65% of the assessed operational emissions are driven from upstream well-to-tank emissions of natural gas that already exist irrespective of the Proposed Development. This is often driven by CH_4 leakage in the supply chain (Bauer, et al., 2022). There is a degree of uncertainty in how much leakage from natural gas is likely, and whether it can be reduced. Whilst studies suggest it is possible that this leakage may be reduced, in turn reducing the carbon footprint of blue hydrogen (Bauer, et al., 2022), there are no reliable projections to base this on currently, so the current well-to-tank emissions of CH_4 extraction are extrapolated over the lifetime of the Proposed Development from current Government conversion factors. Whilst the upstream well-to-tank emissions are a major contributor the GHG assessment, the hydrogen produced will likely be used by industrial users who rely on natural gas.

Summary of GHG Impact

19.3.81 Overall, the GHG emissions from the Proposed Development are Minor to Moderate adverse when viewing the plant boundary in isolation. However, when looking at the hydrogen product and its ability to enable a transition to a lower carbon economy, the Proposed Development has a Significant benefit due to its reduced footprint vs natural gas or other fuels such as diesel or coal. The overall quantitative benefit depends on the end-use of hydrogen.

19.3.82 Overall the Proposed Development would lead to a saving of 43.2 $MtCO_2e$, 63.3 $MtCO_2e$ and 84.3 $MtCO_2e$ over the lifetime of the Proposed Development compared to natural gas, diesel (vehicle usage scenario) and industrial coal (steel plant scenario) respectively - these savings are shown in Plate 19-2. It is anticipated that natural gas will be the main fuel source that is replaced by hydrogen in Phase 1, and uncertain beyond Phase 2.

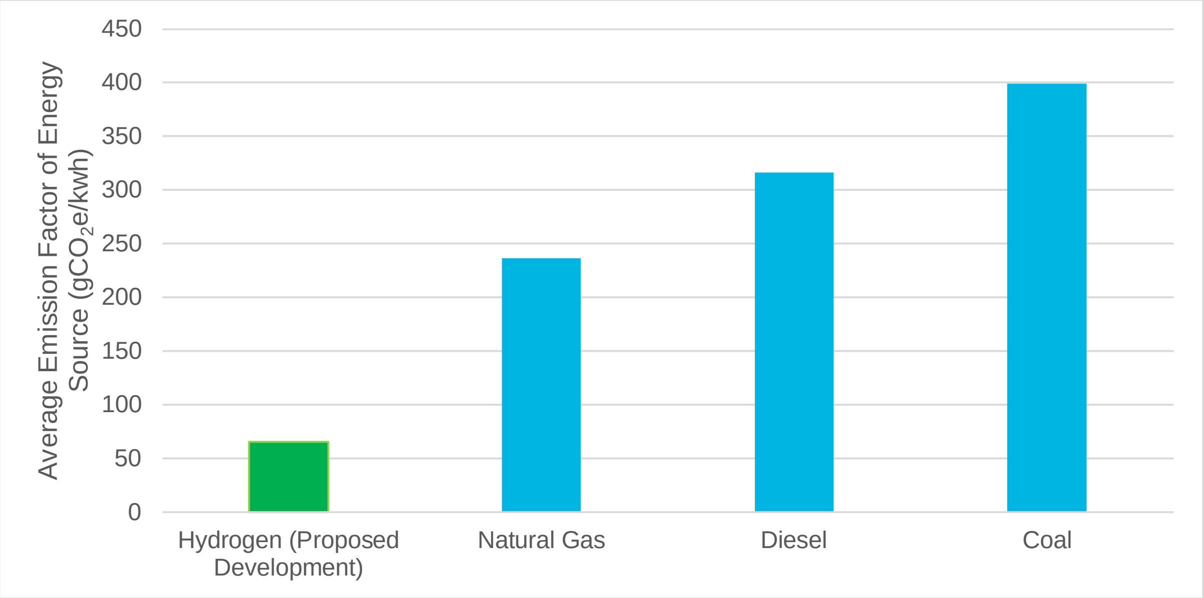

Plate 19-2: Projected Emission Factor of Hydrogen from the Proposed Development, Contrasted with Natural Gas, Diesel and Coal

19.4 Climate Change Resilience Assessment

Methodology

Study Area

19.4.1 The Study Area for the Climate Change Resilience Assessment (CCRA) is the Proposed Development Site itself.

Project Environment

19.4.2 The CCRA considers a '*do something'* scenario with the delivery of the Proposed Development, including its construction, operation and decommissioning.

Sensitive Receptors

19.4.3 Sensitive receptors include workers, occupiers, users, equipment, utilities and associated infrastructure. Sensitive receptors affected by specific climate impacts are detailed in Appendix 19A: Climate Change Resilience Assessment (PEI Report, Volume III).

Climate Variables and Parameters

19.4.4 Climate parameters considered in the CCRA during the construction, operation and decommissioning of the Proposed Development include the following:

- extreme weather events;
- flood risk;
- sea level rise (SLR);
- temperature change; and
- rainfall change.

19.4.5 The CCRA has qualitatively reviewed the Proposed Development's resilience to climate change considering the UK Climate Projections 2018 (UKCP18) (Met Office, 2018a) for the geographical location and timeframe of the Proposed Development (including its construction, operation and decommissioning).

19.4.6 The CCRA has been undertaken for the Proposed Development to identify potential climate change impacts on the Proposed Development and associated receptors, and to consider their potential consequence and likelihood of occurrence, taking account of the measures incorporated into the Proposed Development design.

19.4.7 Climate change projections for the Proposed Development Site during the construction phase have been examined against receptors applicable to this stage, namely the construction workforce, plant, machinery and materials.

Determining Construction Effects

19.4.8 As the construction phase is relatively short from a climatic perspective (4-5 years) and is expected to occur in the immediate future, it is not anticipated that there will be any significant climate impacts. Accordingly, the CCRA for the construction phase uses a qualitative descriptive based approach.

Determining Operational Effects

19.4.9 For the Proposed Development operational phase, potential climate change impacts have been identified using relevant projections from UKCP18. The CCRA considers potential consequence to receptors and the likelihood of occurrence, taking account of the measures incorporated into the Proposed Development design. Receptors when the Proposed Development is complete include the Proposed Development's assets and their operation, maintenance and refurbishment.

19.4.10 The CCRA considers the strategic aims and objectives encompassed within national and local planning policy (refer to Section 19.2), such as the NPS EN-1, the NPPF, the National Planning Policy Guidance on Climate Change, the Tees Valley Climate Change

Strategy and the RCBC Local Plan. These documents detail the broader aims of minimising the adverse impacts of climate change, whilst requiring new development to take climate change considerations into account within their designs. Ways in which resilience of the Proposed Development to climate change can be enhanced have been assessed and mitigation measures identified.

19.4.11 The CCRA considers resilience against both gradual climate change and the risks associated with an increased frequency of extreme weather events as per the UKCP18 (The Met Office, 2018a).

19.4.12 The identification and assessment of climate change resilience within EIA is an area of emerging practice. There is no single prescribed format for undertaking such assessments; therefore, the approach adopted to undertaking and reporting the assessment has drawn on good practice from other similar developments and studies and is aligned with existing guidance such as that of IEMA (IEMA, 2020).

19.4.13 The types of receptors considered vulnerable to climate change include:

- construction phase receptors (i.e. workforce, plant and machinery);
- the Proposed Development assets and their operation, maintenance and refurbishment (e.g. pavements, structures, earthworks and drainage, technology assets, etc.); and
- end-users (e.g. staff and commercial operators etc.).

19.4.14 The potential climate change impacts identified in the CCRA are determined based on the UKCP18 projections. Climatic parameters that are included in the CCRA are detailed in paragraph 19.4.4. Further data has been obtained, where available, for other climate variables and types of extreme acute weather events, namely:

- heavy rainfall events;
- droughts (extended periods of low precipitation);
- heat waves (high temperatures);
- frosts/freezes (low temperatures);
- humidity;
- wind speed;
- storm surges;
- lightning; and
- fog.

Determining Decommissioning Effects

19.4.15 Although the impacts of climate change are likely to be more acute during the Proposed Development decommissioning phase, this phase is expected to be of shorter in duration than construction. Accordingly, the CCRA for the decommissioning phase follows a descriptive based approach.

Scope of CCR Assessment

19.4.16 The scope of the CCRA is set out in Table 19-12.

Table 19-12: CCRA Climate Variable Scope

CLIMATE PARAMETER	CONSIDERED IN CCRA REVIEW	RATIONALE
Extreme weather event	In	The Proposed Development may be vulnerable to extreme weather events such as storm damage, coastal erosion and storm surge to structures and assets.
Precipitation	In	The Proposed Development may be vulnerable to changes in precipitation, for example, pressure on water supply during periods of reduced rainfall, and damage to structures and drainage systems during periods of heavy precipitation and resultant flooding.
Temperature	In	Increased temperatures may increase cooling requirements of the Proposed Development and could impact on structural integrity of buildings and materials.
Sea level rise	In	The Proposed Development Site is located in an area that is susceptible to sea level rise.
Sea temperature	Out	The Proposed Development is not likely to be affected by the small increase in sea temperature during its operational life.
Wind	Out	The impacts of wind on receptors in the surrounding environment and the Proposed Development assets are likely to be no worse relative to baseline conditions.

19.4.17 The CCRA identifies potential climate change impacts and considers their potential consequence and likelihood of occurrence. The following key terms and definitions relating to the CCRA are used:

a) Climate hazard – a weather or climate related event which has the potential to do harm to environmental or community receptors or assets, for example, increased winter precipitation;

b) Climate change impact – an impact from a climate hazard which affects the ability of the receptor or asset to maintain its function or purpose; and

c) Consequence – any effect on the receptor or asset resulting from the climate hazard having an impact.

19.4.18 A stepped approach has been used to assess the impacts of climate change on the Proposed Development as follows:

a) Identify climate hazard;

b) Identify likelihood of climate impact occurring;

c) Identify consequence of impact on the Proposed Development; and

d) Identify significance of effect (likelihood of impact occurring x consequence of impact).

19.4.19 Potential climate hazards are identified based on data extracted from UKCP18 for the climate parameters identified in 19.4.31.

Significance Criteria

19.4.20 For the Proposed Development operational phase, once potential impacts have been identified, the likelihood and consequence of each impact occurring to each receptor (where relevant) have been assessed for the selected future time frame for operation.

19.4.21 The criteria which have been used to determine the likelihood of a climate change impact occurring is detailed in Table 19-13.

Table 19-13: Description of Climate Impact Likelihood

LIKELIHOOD OF CLIMATE IMPACT OCCURRING	DESCRIPTION (PROBABILITY OF OCCURRENCE)
Very Likely	90 - 100% probability that the hazard will occur.
Likely	66 - 90% probability that the hazard will occur.
Possible, about as likely as not	33 - 66% probability that the hazard will occur.
Unlikely	10 - 33% probability that the hazard will occur.
Very Unlikely	0 - 10% probability that the hazard will occur.

19.4.22 Following identification of the likelihood of the climate impact occurring, the consequences of the impact have been assessed according to Table 19-14. The categories and descriptions provided are based on the IEMA climate change resilience and adaptation guidance.

Table 19-14: Climate Impact Consequence Descriptions

CONSEQUENCE OF IMPACT	DESCRIPTION
Very High	• Permanent damage to structures/assets; • Complete loss of operation/service; • Complete/partial renewal of infrastructure; • Serious health effects, possible loss of life; • Extreme financial impact; and • Exceptional environmental damage.
High	• Extensive infrastructure damage and complete loss of service; • Some infrastructure renewal; • Major health impacts; • Major financial loss; and • Considerable environmental impacts.
Medium	• Partial infrastructure damage and some loss of service; • Moderate financial impact; • Adverse effects on health; and • Adverse impact on the environment.
Low	• Localised infrastructure disruption and minor loss of service; • No permanent damage, minor restoration work required; and • Small financial losses and/or slight adverse health or environmental effects.
Very Low	• No damage to infrastructure; • No impacts on health or the environment; and • No adverse financial impact.

19.4.23 Engagement has been undertaken with relevant environmental disciplines as included within this PEI Report and the engineering design team to discuss the CCRA and identify mitigation measures for incorporation into the Proposed Development design. Measures to adapt the Proposed Development are identified where potential climate change consequences are identified as being potentially significant.

19.4.24 The significance is determined by:

Likelihood of climate hazard occurring x Consequence to receptor if climate hazard occurs

19.4.25 The significance level of the identified climate risk is determined through a combination of the likelihood of the hazard occurring and the severity of the potential consequence, as outlined in Table 19-15.

Table 19-15: Climate Change Impact Significance Matrix

		LIKELIHOOD OF CLIMATE CHANGE HAZARD OCCURRING				
		VERY UNLIKELY	UNLIKELY	POSSIBLE	LIKELY	VERY LIKELY
CONSEQUENCE	Very Low	Negligible	Negligible	Negligible	Negligible	Negligible
	Low	Negligible	Minor	Minor	Minor	Minor
	Medium	Negligible	Minor	Moderate	Moderate	Moderate
	High	Negligible	Minor	Moderate	Major	Major
	Very High	Negligible	Minor	Moderate	Major	Major

19.4.26 The overall methodology for the CCRA is summarised in Plate 19-3.

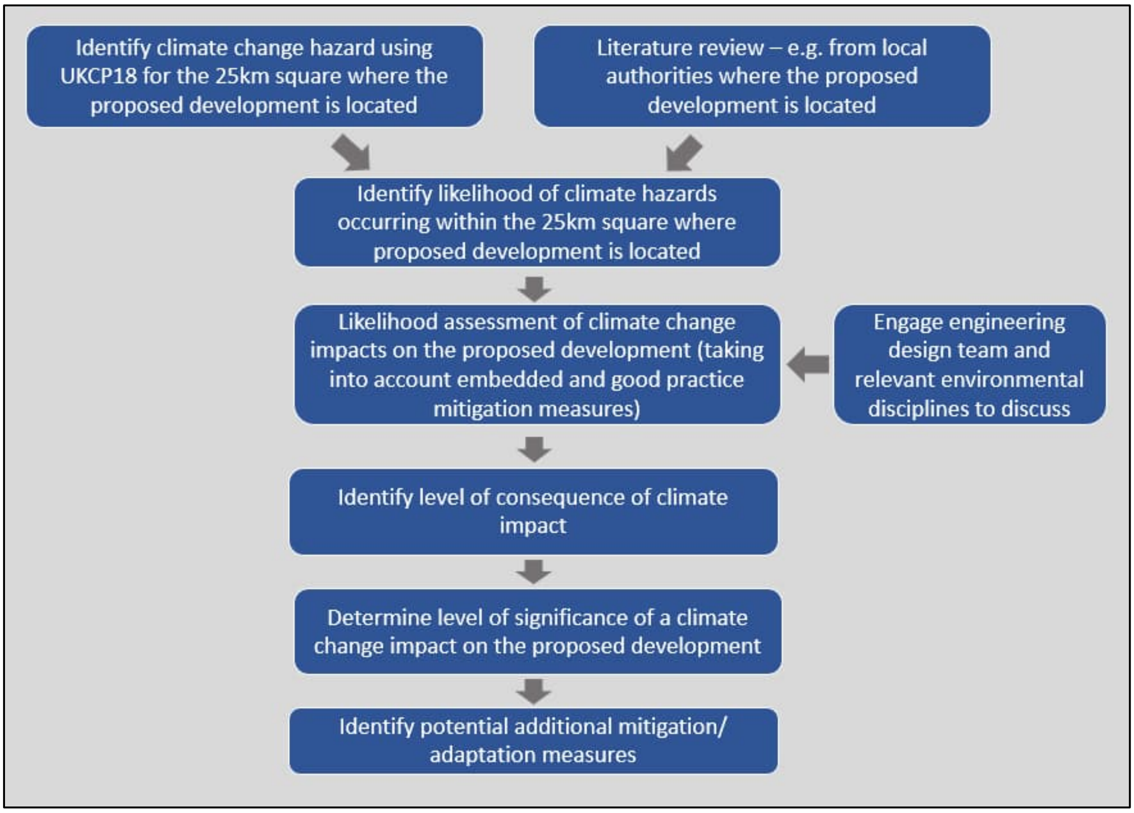

Plate 19-3: CCRA Methodology

Baseline Conditions

Existing Baseline

19.4.27 The current baseline for the CCRA is based on historic climate data obtained from the Met Office (2020) recorded by the closest meteorological station to the Proposed Development Site (Stockton-on-Tees located approximately 11 km from the Proposed Development Site) for the period 1981 – 2010 – refer to Table 19-16. This baseline considers how resilient the Proposed Development is to current and projected future climates.

Table 19-16: Historic Climate Data

CLIMATIC VARIABLE	MONTH	VALUE
Average annual maximum daily temperature (°C)	-	13.1
Warmest month on average (°C)	July	20.4
Coldest month on average (°C)	December and January	0.7
Mean annual rainfall levels (mm)	-	574.2
Wettest month on average (mm)	August	60.6
Driest month on average (mm)	February	32.9

19.4.28 The Met Office historic 10-year averages for the 'East and North East England' region identify gradual warming (although not uniformly so) between 1970 and 2019, with increased rainfall. Information on mean maximum annual temperatures and mean annual rainfall is summarised in Table 19-17.

19.4.29 In comparison to the historic climate data, Stockton-on-Tees appears somewhat drier than the average for the region. As described by the Met Office (2016), rainfall is greater across the Pennines and "*decreases as land falls eastwards, such that the east coast is one of the driest parts of the UK with less than 600 mm in places such as Tees-side and the Northumbrian coast*".

Table 19-17: Historic 10-year Averages for Temperature and Rainfall for the East and North East England

CLIMATE PERIOD	CLIMATE VARIABLE	
	MEAN MAXIMUM ANNUAL TEMPERATURES (°C)	MEAN ANNUAL RAINFALL (MM)
1970 - 1979	12.0	698.2
1980 - 1989	12.0	748.2

CLIMATE PERIOD	CLIMATE VARIABLE	
	MEAN MAXIMUM ANNUAL TEMPERATURES (^{O}C)	MEAN ANNUAL RAINFALL (MM)
1990 - 1999	12.7	720.2
2000 - 2009	13.2	824.9
2010 - 2019	13.1	796.2

Future Baseline

19.4.30 The future baseline for the CCRA is based on future UKCP18 data from the Met Office for the Stockton-on-Tees area (The Met Office, 2019a). This projection data provides probabilistic indications of how global climate change is likely to affect areas of the UK using pre-defined climate variables and time periods.

19.4.31 For the purpose of the assessment, UKCP18 probabilistic projections for pre-defined 20-year periods for the following average climate variables have been obtained and analysed:

- mean annual temperature;
- mean summer temperature;
- mean winter temperature;
- maximum summer temperature;
- minimum winter temperature;
- mean annual precipitation;
- mean summer precipitation;
- mean winter precipitation; and
- sea level rise.

19.4.32 Projected variables are presented in Table 19-18 and Table 19-19. UKCP18 probabilistic projections have been analysed for the 25 km grid square in which the Proposed Development Site is located. These figures are expressed as temperature/ precipitation anomalies in relation to the 1981 - 2000 baseline. This baseline was selected as it provides projections for 20-year time periods (e.g. 2020 - 2039) for the parameters analysed within the assessment compared to the 30-year land-based projections that would be generated from the 1981 - 2010 baseline.

19.4.33 UKCP18 uses a range of possible scenarios, classified as Representative Concentration Pathways (RCPs), to inform differing future emission trends. These RCPs *"… specify the concentrations of greenhouse gases that will result in total radiative forcing increasing by a target amount by 2100, relative to preindustrial levels."* RCP 8.5 is considered to be the worst-case global scenario with the greatest concentration of GHGs in the atmosphere and has been used for the purposes of this assessment as a worst-case scenario.

19.4.34 As the design life of the Proposed Development is relatively short (25 years from completion of phase 2) and does not extend far beyond the point where the emissions scenarios begin to differ significantly (2040), only the RCP 8.5 emissions scenario has been selected for analysis.

19.4.35 Construction of the Proposed Development is expected to take approximately five years. Construction of Phase 1 is likely to last approximately three years. Phase 2 works will commence thereafter (2028) and last a further two to three years, with construction expected to be completed by the end of 2030. Please refer to Chapter 5: Construction Programme and Management (PEI Report, Volume I) for further detail.

19.4.36 Power generation and carbon capture are expected from 2028 for up to 28 years (25 years from completion of phase 2). Therefore, the CCRA has considered a scenario that reflects a high level of GHG at the 10%, 50% and 90% probability levels up to the 2069 projection to assess the impact of climate change over as much of the lifetime of the Proposed Development as possible.

Table 19-18: Projected Changes in Temperature Variables (°C), 50% Probability (10% and 90% Probability in Parenthesis)

CLIMATE VARIABLE	TIME PERIOD		
	2020-2039	2030-2049	2050-2069
Mean annual air temperature anomaly at 1.5 m (°C)	+1.0 (+0.4 to +1.6)	+1.3 (+0.6 to +2.1	+2.1 (+1.0 to +3.2)
Mean summer air temperature anomaly at 1.5 m (°C)	+1.0 (+0.2 to +1.8)	+1.3 (+0.3 to +2.3)	+2.4 (+0.7 to +4.2)
Mean winter air temperature anomaly at 1.5 m (°C)	+1.0 (0.0 to +1.9)	+1.3 (+0.1 to +2.5)	+1.9 (+0.5 to +3.5)
Maximum summer air temperature anomaly at 1.5 m (°C)	+1.1 (+0.2 to +2.1)	+1.5 (+0.3 to +2.7)	+2.6 (+0.8 to +4.6)
Minimum winter air temperature anomaly at 1.5 m (°C)	+1.0 (+0.0 to +2.0)	+1.3 (+0.2 to +2.4)	+1.9 (+0.5 to +3.3)

Table 19-19: Projected Changes in Precipitation Variables (%), 50% Probability (10% and 90% Probability in Parenthesis)

CLIMATE VARIABLE	TIME PERIOD		
	2020-2039	2030-2049	2040-2059
Annual precipitation rate anomaly (%)	+4.5 (-1.5 to +11.2)	+1.5 (-3.5 to +6.9)	+0.8 (-6.0 to +8.3)
Summer precipitation rate anomaly (%)	-2.0 (-16.8 to +14.7)	-5.1 (-19.9 to +11.3)	-16.4 (-36.6 to +5.5)
Winter precipitation rate anomaly (%)	+9.5 (-3.0 to +22.8)	+12.0 (-1.2 to +26.3)	+14.6 (-4.3 to +35.7)

19.4.37 Sea level rise may increase up to 14 cm when Proposed Development operations start (approximately 2028 and up to 33 cm when operations are completed, decommissioning starts (from 2056). The ranges of projected sea level rise from the 1981 - 2000 baseline are detailed in Table 19-20.

Table 19-20: Sea Level Rise Projections

	YEAR			
	2022	2028	2056	2071
Sea level anomaly (m)	+0.08 (+0.06 to +0.11)	+0.11 (+0.08 to +0.14)	+0.26 (+0.19 to +0.33)	+0.39 (+0.29 to +0.53)

19.4.38 Sea temperature change projections are more variable, but under RCP 8.5 a rise in global sea surface temperature of 1.5°C by 2050 is predicted, and 3.2°C by 2100, relative to 1870 - 1899 temperatures. In UK waters, mean annual sea temperatures have risen by 0.8°C since 1870, and have shown a consistent warming trend from the 1970s onwards (Genner et al., 2017). According to Lowe et al., (2009), the seas around the UK are projected to be 1.5 - 4 °C warmer by 2100.

19.4.39 Using the climate variable likelihood data for future baselines and the definitions for likelihood (Table 19-13), the likelihood of occurrence of potential climate hazards is detailed in Table 19-21.

Table 19-21: Potential Climate Hazards and Likelihood of Occurrence (from UKCP18 Projections)

CLIMATE VARIABLE	POTENTIAL HAZARD	2020-2039 LIKELIHOOD	2030-2049 LIKELIHOOD	2050-2069 LIKELIHOOD
Mean annual air temperature anomaly at 1.5 m (°C)	Increase in mean annual air temperature	Very likely	Very likely	Very likely
Mean summer air temperature anomaly at 1.5 m (°C)	Increase in mean summer air temperature	Very likely	Very likely	Very likely
Mean winter air temperature anomaly at 1.5 m (°C)	Increase in mean winter air temperature	Very likely	Very likely	Very likely
Maximum summer air temperature anomaly at 1.5 m (°C)	Increase in maximum summer air temperature	Very likely	Very likely	Very likely
Minimum winter air temperature anomaly at 1.5 m (°C)	Increase in minimum winter air temperatures	Very likely	Very likely	Very likely
Annual precipitation rate anomaly (%)	Decrease in annual precipitation rate	Unlikely	Unlikely	Possible
Summer precipitation rate anomaly (%)	Decrease in summer precipitation rate	Possible	Likely	Likely
Winter precipitation rate anomaly (%)	Increase in winter precipitation rate	Very likely	Very likely	Very likely
Sea level rise (m)	Increase in sea level	Very likely	Very likely	Very likely

CLIMATE VARIABLE	POTENTIAL HAZARD	2020-2039 LIKELIHOOD	2030-2049 LIKELIHOOD	2050-2069 LIKELIHOOD
Sea temperature rise (°C)	Increase in sea surface temperature	Very likely	Very likely	Very likely

19.4.40 The 2019 State of the UK Climate Report (Kendon et al., 2020) states that there are *"no compelling trends in storminess when considering maximum gust speeds over the last five decades"*, therefore an increase in storm intensity is currently considered unlikely.

19.4.41 Kendon et al., (2020) states that there has been a decline in the longest sequence of consecutive dry days. However, projected drier summers are suggestive of a drying trend. Therefore, an increase in droughts is currently considered possible.

19.4.42 Research by Sanderson et al., (2017) into the historical trends of heatwave frequency in the UK found variable results, with some weather stations recording a decline in very long heatwaves and others an increase in short heatwaves. Accordingly, the likelihood of an increase in heatwaves is considered possible.

Proposed Development Design and Impact Avoidance

Construction

19.4.43 Full details of design measures embedded in the Proposed Development design that reduce its vulnerability to climate change are detailed Chapter 9: Surface Water, Flood Risk and Water Resources and Chapter 10: Geology, Hydrogeology and Contaminated Land (PEI Report, Volume I) - examples of these measures include:

- storage of topsoil and other construction materials stored outside of the 1 in 100-year floodplain to protect materials from high rainfall and flooding events or sea level rise;
- suitable storage and bunding of pollutants to protect from high rainfall events or sea level rise. This will be further supported by a Water Management Plan and a Site Emergency Response Plan;
- laydown and welfare areas will be laid with permeable membranes to protect the site from high rainfall and flooding events or sea level rise;
- the Contractor will monitor weather forecasts and receive Environment Agency flood alerts and plan works accordingly, protecting workers and resources from any extreme weather conditions such as storms, flooding or heatwaves.

19.4.44 In addition to the above, mitigation measures to reduce the vulnerability of the Proposed Development construction phase to climate change will be detailed in the Framework CEMP which will be included within the ES and will accompany the DCO Application.

Operation

19.4.45 Full details of embedded design measures that reduce the vulnerability of the Proposed Development are contained within other technical disciplines within this PEI Report, such as Chapter 9: Surface Water, Flood Risk and Water Resources (PEI Report, Volume I). Examples of such measures include:

- Suitable storage and bunding of pollutants to protect from high rainfall events or sea level rise. This will be supported by a Site Emergency Response Plan.
- Cabling will be buried underground, insulating against overheating during heatwaves.
- Installation of a suitable surface water drainage network and management system through the Surface Water Drainage Strategy, Sustainable drainage systems (SuDS), to protect the Proposed Development Site from high rainfall events or sea level rise. This will be supported by a Surface Water Maintenance and Management Plan.
- To mitigate flood risk associated with sea level rise, a raised development platform will be provided for the Proposed Development to ensure the Finished Floor Levels will be no lower than 7.5m, allowing for continued operation in the occurrence of a flood event. This raised platform will also allow for additional below ground attenuation and gravity discharge to support the proposed drainage system.

Decommissioning

19.4.46 At this stage, limited specific mitigation measures have been identified for the decommissioning phase of the Proposed Development. A DEMP would be produced to appropriate guidance and legislation at the time and is likely be similar to that of the construction phase but reflect future climatic conditions at that point in time.

Likely Impacts and Effects

19.4.47 This section presents a summary of the findings of the CCRA for the construction, operation and decommissioning of the Proposed Development. Components of the Proposed Development that have been considered include all infrastructure, plant and machinery, all workers, staff or visitors on-site and materials.

19.4.48 This section identifies any likely significant effects that are predicted to occur and then highlights any additional mitigation and enhancement measures that could add an additional beneficial contribution on top of the embedded measures.

Description of Potential Effects

19.4.49 The potential impacts and effects of projections for climate change to the Proposed Development are detailed in Appendix 19A: Climate Change Resilience Assessment (PEI Report, Volume III), and are based upon that scoped into the assessment (Table 19-12).

19.4.50 Potential climate change impacts, the likelihood and consequences to the construction, operation and decommissioning of the Proposed Development, together with the adaptation methods to increase the resilience of the Proposed Development are detailed in Appendix 19A: Climate Change Resilience Assessment (PEI Report, Volume III).

Summary of CCR Impacts

19.4.51 A range of climate change hazards and their potential impact upon the Proposed Development have been identified. The measures embedded within the Proposed Development design as detailed herein are deemed sufficient to reduce the likelihood or consequence of an impact occurring as a result of these projected climate hazards. As such, no significant resilience risks have been identified.

Mitigation and Enhancement Measures

19.4.52 The management of impacts and the application of mitigation/adaption measures during Proposed Development construction will be enforced through the Framework CEMP.

19.4.53 No additional mitigation measures are required due to the lack of significant climate change risks to the Proposed Development.

Limitations and Difficulties

19.4.54 The CCRA assumes that the defined mitigation measures will be incorporated into the Proposed Development design. No additional mitigation has been identified as necessary for any stage of the Proposed Development.

19.4.55 While modelled climate change projections represent anticipated average weather conditions, they do not capture the full range of possible future severe weather events (e.g. droughts, heatwaves and prolonged heavy rainfall).

19.4.56 The CCRA is limited by the availability of data and Proposed Development design information at the date this assessment was prepared.

Residual Effects and Conclusions

19.4.57 No residual CCR effects have been identified. As a result of this, no further mitigation measures are recommended.

19.5 In-Combination Climate Change Impact (ICCI) Assessment

19.5.1 This ICCI assessment aims to identify any impacts to receptors in the surrounding environment or communities that occur due to the combined impacts of climate change and the construction and operation of the Proposed Development. Given that the preliminary nature of the assessment, it is not currently possible to undertake a full ICCI assessment. As such, discussions with design and technical assessment teams will be undertaken between the issue of this PEI Report and the issue of the ES to identify any possible in-combination impacts and effects. The results will be presented in the ES.

Methodology

Study Area

19.5.2 The Study Areas used for the ICCI assessment comprises the Study Areas defined in each of the relevant topic chapters in this PEI Report (Chapters 8 – 24: PEI Report Volume I). This assessment aims to determine the influence of climate change and related impacts to the identified receptors in each of the assessments in those chapters.

19.5.3 The ICCI assessment considers the ways in which projected climate change will influence the significance of the effects of the Proposed Development on receptors in the surrounding environment.

Project Environment

19.5.4 The ICCI considers a '*do something*' scenario with the delivery of the Proposed Development, including its construction, operation and decommissioning.

Sensitive Receptors

19.5.5 The ICCI assessment considers the sensitive receptors as identified by each technical discipline in Chapters 8 to 24 of this PEI Report (PEI Report, Volume I). The ICCI assessment is undertaken by individual technical disciplines in regard to the identified sensitive receptors in each assessment.

Determining Effects

19.5.6 The methodology for determining climate change impact effects can be considered the same as the CCRA and is undertaken by technical specialists responsible for their applicable chapter.

Scope

19.5.7 The scope of the ICCI is considered the same as that of the CCRA, as presented in Table 19-12.

Significance Criteria

19.5.8 Once climate hazards are identified for the receptors associated with the Proposed Development, the likelihood of their occurrence and the sensitivity of the receptor is considered in order to determine the likelihood of a climate impact occurring during the Proposed Development's lifespan is categorised as per Table 19-22.

Table 19-22: ICCI Climate Impact Likelihood Descriptions

LEVEL OF LIKELIHOOD OF CLIMATE IMPACT OCCURRING	QUALITATIVE DESCRIPTION	QUANTITATIVE DESCRIPTION
Very likely	Likely that the impact will occur many times (reoccurs frequently).	90-100% probability that the impact will occur during the life of the Proposed Development.

LEVEL OF LIKELIHOOD OF CLIMATE IMPACT OCCURRING	QUALITATIVE DESCRIPTION	QUANTITATIVE DESCRIPTION
Likely	Likely that the impact will occur sometimes (reoccurs infrequently).	66-90% probability that the impact will occur during the life of the Proposed Development.
Possible, about as likely as not	Possible that the impact will occur (has occurred rarely).	33-66% probability that the impact will occur during the life of the Proposed Development.
Unlikely	Unlikely that the impact will occur (not known to have occurred).	10-33% probability that the impact will occur during the life of the Proposed Development.
Very unlikely	Almost inconceivable that the impact will occur.	0-10% probability that the impact will occur during the life of the Proposed Development.

19.5.9 The likelihood of a climate hazard occurring and the likelihood of an impact to a receptor is then combined to determine the likelihood of an ICCI occurring. This matrix is illustrated in Table 19-23.

Table 19-23: ICCI Occurrence Matrix

LEVEL OF LIKELIHOOD OF CLIMATE IMPACT OCCURRING	DEFINITION OF LIKELIHOOD
High	Likelihood of climate hazard occurring is high and impact is always/almost always going to occur.
Moderate	Likelihood of climate hazard occurring is high and impact occurs often or the likelihood of climate hazard occurring is moderate and impact is likely to occur always/almost always.
Low	Likelihood of climate hazard occurring is high, but impact rarely occurs or the likelihood of climate hazard occurring is moderate and impact sometimes occurs or the likelihood of climate hazard occurring is low and impact is likely to occur always/almost always.
Negligible	All other eventualities - highly unlikely but theoretically possible.

19.5.10 Once the likelihood of an ICCI has been identified, the assessment then considers how this will affect the significance of the identified effects.

19.5.11 The ICCI consequence criteria are defined in Table 19-24 and are based on the change to the significance of the effect already identified by the applicable environmental discipline. To assess the consequence of an ICCI each discipline has assigned a level of consequence to an impact based on the criteria description and their discipline assessment methodology.

Table 19-24: ICCI Consequence Criteria

CONSEQUENCE	CONSEQUENCE CRITERIA
High	The climate change parameter in-combination with the effect of the Proposed Development causes the significance of the effect of the Proposed Development on the resource/receptor, as defined by the topic, to increase from negligible, low, or moderate to major.
Moderate	The climate change parameter in-combination with the effect of the Proposed Development causes the significance of effect defined by the topic to increase from negligible or low, to moderate.
Low	The climate change parameter in-combination with the effect of the Proposed Development, causes the significance of effect defined by the topic, to increase from negligible to low.
Negligible	The climate change parameter in-combination with the effect of the Proposed Development does not alter the significance of the effect defined by the topic.

19.5.12 The significance of potential effects is determined using the matrix in Table 19-25. Where an effect has been identified as moderate or high is classed as a significant ICCI effect. If significant ICCI effects are assessed, then appropriate additional mitigation measures are identified.

Table 19-25: ICCI Significance Matrix

CONSEQUENCE	LIKELIHOOD			
	NEGLIGIBLE	LOW	MODERATE	HIGH
Negligible	Not Significant	Not Significant	Not Significant	Not Significant
Low	Not Significant	Not Significant	Not Significant	Significant
Moderate	Not Significant	Not Significant	Significant	Significant
High	Not Significant	Significant	Significant	Significant

Baseline Conditions

19.5.13 The existing and future baseline conditions for the ICCI are the same as those described for the CCRA (see paragraphs 19.4.18 to 19.4.22) and in topic chapters.

Likely Impacts and Effects

19.5.14 Given that the preliminary nature of the assessment, it is not currently possible to undertake a full ICCI assessment. As such, discussions with design and technical assessment teams will be undertaken between the issue of this PEI Report and the issue of the ES to identify any possible in-combination impacts and effects. The results will be presented in the ES.

Mitigation and Enhancement Measures

19.5.15 Discussions with design and technical assessment teams will be undertaken between the issue of this PEI Report and the issue of the ES to identify any possible mitigation and enhancement measures as associated with ICCI effects. These results will be presented in the ES.

Assumptions and Limitations

19.5.16 While modelled climate change projections represent anticipated changes to average weather conditions, they cannot predict the frequency and severity of acute events such as droughts, heatwaves and prolonged heavy rainfall. Therefore, the ICCI assessment is based upon UKCP18 predictions for general changes in climate conditions, and only a high-level assessment of acute events will be included in this assessment.

19.5.17 The ICCI assessment is limited by the availability of data and information at this stage of the assessment. The full ICCI assessment will be detailed in the ES.

Residual Effects and Conclusions

19.5.18 No residual effects or conclusions can be presented at this stage. The full ICCI assessment results and conclusions will be presented in the ES.

19.6 References

- Allen, M. R. et al., 2018. A solution to the misrepresentations of CO2-equivalent emissions of short-lived climate pollutants under ambitious mitigation. *npj climate and atmospheric science,* Volume 1.
- Bauer, C. et al., 2022. On the climate impacts of blue hydrogen production. *Sustainable Energy Fuels,* Volume 6, pp. 66-75.
- BEIS, 2021. *Draft Overarching National Policy Statment for Energy (EN-1).* [Online]
  Available at:
  https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015233/en-1-draft-for-consultation.pdf
  [Accessed 23 February 2023].
- BEIS, 2022. *2022 Government Greenhouse Gas Conversion Factors for COmpany Reporting: Methodology Paper for Conversion Factors,* s.l.: BEIS.
- BEIS, 2022. *Energy and emissions projections.* [Online]
  Available at: https://www.gov.uk/government/collections/energy-and-emissions-projections
  [Accessed 13 February 2023].
- BEIS, 2022. *Greenhouse gas reporting: conversion factors ,* s.l.: s.n.
- Brandl, P., Bui, M., Hallet, J. P. & Mac Dowell, N., 2020. Beyond 90% capture: Possible, but at what cost?. *International Journal of Greenhouse Gas Control,* Volume 105.
- BSI, 2019a. *Greenhouse Gases. Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.,* s.l.: s.n.
- BSI, 2019b. *Greenhouse gases. Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.,* s.l.: s.n.
- BSI, 2023. *PAS 2080:2023 Carbon Management in Infrastructure,* s.l.: s.n.
- Climate Change Committee, 2020. *The Sixth Carbon Budget.* [Online]
  Available at: https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf
  [Accessed 13 September 2023].
- Department for Business, Energy and Industrial Strategy, 2023. *UK Low Carbon Hydrogen Standard,* London: UK Government.
- Department for Energy Security and Net Zero, 2023. *Draft Overarching National Policy Statement for Energy (EN-1),* s.l.: UK Government.
- Department for Energy Security and Net Zero, 2023. *Draft Overarching National Policy Statenment for Energy (EN-4),* s.l.: UK Government.

- Department for Energy Security and Net Zero, 2023. *Overarching National Policy Statement for Energy (EN-1).* [Online]
  Available at:
  https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147380/NPS_EN-1.pdf
  [Accessed 30 May 2023].
- Department for Energy Security and Net Zero, 2023. *Overarching National Policy Statement for Energy (EN-5),* s.l.: UK Government.
- Department of Energy and Climate Change, 2011a. *Overarching National Policy Statement for Energy (EN-1).* [Online]
  Available at:
  https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf
  [Accessed 23 February 2023].
- Department of Energy and Climate Change, 2011b. *National Policy Statement for Fossil Fuel Electricity Generating Infrastructure (EN-2).* [Online]
  Available at:
  https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf
  [Accessed 23 February 2023].
- Department of Energy and Climate Change, 2011b. *National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4),* s.l.: UK Government.
- Department of Energy and Climate Change, 2011b. *Overarching National Policy Statement for Energy (EN-1).* [Online]
  Available at:
  https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf
  [Accessed 23 February 2023].
- Department of Energy and Climate Change, 2011c. *National Policy Statement for Electricity Networks and Infrastructure (EN-5),* s.l.: UK Government.
- ESNZ, 2023. *Greenhouse gas conversion factors for company reporting,* s.l.: Department for Energy Security & Net Zero.
- EU Commission, 2010. *Commission Decision of 10 June 2010 on Guidelines for the Calculation of Land Carbon Stocks for the Purpose of Annex V to Directive 2009/28/EC.* [Online]
  Available at: https://www.legislation.gov.uk/eudn/2010/335/2010-06-10
  [Accessed 23 February 2023].
- EU Commission, 2013. *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment.* [Online]
  Available at: https://circabc.europa.eu/ui/group/3b48eff1-b955-423f-9086-0d85ad1c5879/library/94b9394e-cc9e-4859-94ca-95ccecb43422?p=1&n=-

1&sort=name_ASC
[Accessed 23 February 2023].

- Exergia, 2015. *Study on actual GHG data for diesel, petrol, kerosene and natural gas,* s.l.: European Commission.
- Government, U., 2017. *The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.* [Online]
Available at: https://www.legislation.gov.uk/uksi/2017/572/made
[Accessed 13 September 2023].
- Government, U., 2017. *The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.* [Online]
Available at: https://www.legislation.gov.uk/uksi/2017/572/made
[Accessed 13 September 2023].
- Greater London Authority, 2022. *Whole Life-Cycle Carbon Assessments.* [Online]
Available at: https://www.london.gov.uk/sites/default/files/lpg_-_wlca_guidance.pdf
[Accessed 23 February 2023].
- HBC, 2018. *Hartlepool Borough Council Local Plan,* s.l.: Hartlepool Borough Council.
- Howarth, R. W. & Jacobson, M. Z., 2021. How green is blue hydrogen?. *Energy Science & Engineering,* 9(10), pp. 1676-1687.
- ICE, 2019. *Embodied Carbon - The ICE Database,* s.l.: s.n.
- IEMA, 2022. *Assessing Greenhouse Gas Emissions and Evaluating their Significance: 2nd Edition,* s.l.: IEMA.
- IPCC, 2023. *Global Warming Potentials (IPCC Second Assessment Report).* [Online]
Available at: https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-unfccc/global-warming-potentials
[Accessed 14 February 2023].
- IPCC, 2023. *Synthesis Report of the IPCC Sixth Assessment Report (AR6),* s.l.: IPCC.
- JBA Consulting, 2018. *Level 1 Strategic Flood Risk Assessment Update.* [Online]
Available at: https://www.redcar-cleveland.gov.uk/sites/default/files/2022-04/RCBC%20Level%201%20SFRA%20Update%202016.pdf
[Accessed 23 February 2023].
- Ministry of Housing, Communities and Local Government, 2019b. *National Planning Policy Guidance on Climate Change.* [Online]
Available at: https://www.gov.uk/guidance/climate-change
[Accessed 23 February 2023].

- Ministry of Housing, Communities and Local Government, 2021. *National Planning Policy Framework.* [Online]
  Available at:
  https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf
  [Accessed 25 May 2023].
- NIC, 2020. *Net Zero: Opportunities for the power sector.* [Online]
  Available at: https://nic.org.uk/studies-reports/net-zero-opportunities-for-the-power-sector/
  [Accessed 23 February 2023].
- OneClick LCA, 2021. *Embodied Carbon Benchmarks for European Buildings,* s.l.: OneClick.
- Parsons Brinckerhoff Ltd & Genecon, 2009. *North & South Tees Industrial Development Framework.* [Online]
  Available at:
  https://www.hartlepool.gov.uk/download/downloads/id/2986/hlp04_16_north_and_south_tees_industrial_development_framework_2009pdf.pdf
  [Accessed 23 February 2023].
- Redcar & Cleveland Borough Council, 2019b. *Redcar and Cleveland Borough Council Local Plan.* [Online]
  Available at: https://www.redcar-cleveland.gov.uk/planning/local-plan/redcar-and-cleveland-local-plan
  [Accessed 23 February 2023].
- Redcar & Cleveland Borough, 2019a. *A meeting of the Borough Council was held on 28 March 2019 at the Redcar & Cleveland Leisure and Community Heart.* [Online]
  Available at: https://www.redcar-cleveland.gov.uk/Democracy/DecisionMaking/MeetingCabinet/CabinetPapers/28.03.19%20Borough%20Council%20Minutes.pdf
  [Accessed 07 May 2020].
- STBC, 2019. *Stockton-on-Tees Borough Council Local Plan,* s.l.: Stockton-on-Tees Borough Council.
- STBC, 2022. *Environmental Sustainability and Carbon Reduction Strategy 2022 to 2032.* [Online]
  Available at: https://stockton.gov.uk/media/3265/Environmental-Sustainability-and-Carbon-Reduction-Strategy-2022-2032/pdf/Environmental_Sustainability_Carbon_Reduction_Strategy_2022-2032_Accessible.pdf?m=637987399483800000
  [Accessed 23 February 2023].
- Tees Valley Unlimited, 2010. *Tees Valley Climate Change Strategy.* [Online]
  Available at: https://www.stockton.gov.uk/media/2349/tees-valley-climate-

change-action-plan.pdf
[Accessed 23 February 2023].

- UK Government , 2022. *United Kingdom of Great Britain and Northern Ireland's Nationally Determined Contribution.* [Online]
Available at:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1109429/uk-nationally-determined-contribution.pdf
[Accessed 22 February 2023].
- UK Government, 2008. *Climate Change Act 2008.* [Online]
Available at: https://www.legislation.gov.uk/ukpga/2008/27/contents
[Accessed 22 February 2023].
- UK Government, 2009. *Marine and Coastal Access Act 2009.* [Online]
Available at: https://www.legislation.gov.uk/ukpga/2009/23/contents
[Accessed 23 February 2023].
- UK Government, 2017, updated 2018. *The Clean Growth Strategy. Leading the way to a low carbon future.* [Online]
Available at:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf
[Accessed 23 February 2023].
- UK Government, 2017. *The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.* [Online]
Available at: https://www.legislation.gov.uk/uksi/2017/572/made
[Accessed 13 September 2023].
- UK Government, 2019. *The Climate Change Act 2008 (2050 Target Amendment) Order 2019.* [Online]
Available at: https://www.legislation.gov.uk/ukdsi/2019/9780111187654
[Accessed 22 February 2022].
- UK Government, 2021. *North East Inshore and North East Offshore Marine Plan.* [Online]
Available at:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/995743/FINAL_North_East_Marine_Plan.pdf
[Accessed 23 February 2023].
- UK Government, 2022. *Final UK greenhouse gas emissions national statistics: 1990 to 2020.* [Online]
Available at: https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2020
[Accessed 23 February 2023].
- UK Government, 2023. *Carbon Budgets.* [Online]
Available at: https://www.gov.uk/guidance/carbon-budgets#setting-of-the-sixth-

carbon-budget-2033-2037
[Accessed 13 February 2023].

- UNFCCC, 2016. *Conference of the Parties, Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015.* [Online]
  Available at: https://unfccc.int/resource/docs/2015/cop21/eng/10.pdf
  [Accessed 22 February 2023].
- Warwick, N. et al., 2022. *Atmospheric implications of increased Hydrogen Use,* s.l.: BEIS.
- World Resource Institute & World Business Council for Sustainable Development, 2004. *A Corporate Accounting and Reporting Standard. The Greenhouse Gas Protocol.* [Online]
  Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010103/EN010103-000905-NZT%20DCO%206.2.21%20ES%20Vol%20I%20Chapter%2021%20Climate%20Change.pdf
  [Accessed 23 February 2023].